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ART. XLII.—*On supposed changes in the Nebula* M. 17 = h. 2008 = G. C. 4403. (R. A. $18^h\ 12^m\ 33^s.1$; N. P. D. 106° 13′ 36″; 1860·0); by EDWARD S. HOLDEN.*

I. *Historical Notes—Observations*:—This nebula was discovered by Messier and is number 17 of his list (*Connaissance des Tems* 1784). It has been carefully studied since 1800, by Sir John Herschel (1833–37), Lamont (1837), Mason (1839), Lassell (1862), Huggins (1865), Trouvelot (1875), and Trouvelot and myself (1875). These observations, so far as they are published, are to be found in the following works:—

HERSCHEL: Observations of Nebulæ, etc., made at Slough; *Phil. Trans.*, 1833, p. 498 and Plate XII, fig. 35.
HERSCHEL: *Results of Astronomical Observations at the Cape of Good Hope*, p. 8 and Plate II, fig. 1.
LAMONT: *Ueber die Nebelflecken*, 1837, fig. X.
LAMONT: *Annalen der K. Sternwarte bei München*, band xvii, p. 332 and fig. 21, Plate VIII.
MASON: *Transactions American Phil. Soc.*, vol. vii, 1840, p. 165, Plate VI.
LASSELL: *Mem. R. A. S.*, vol. xxxvi; Plates VII, VIII, figs. 33, 33A.
HUGGINS: *Philosopical Transactions* 1866, p. 385.

The later observations are unpublished.

I extract from these various authorities such portions as will be of use for subsequent reference.

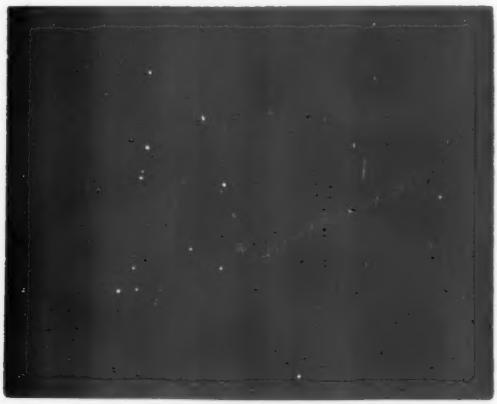
From Herschel's paper (*Phil. Trans.*, 1833):—

"The figure of this nebula is nearly that of a Greek capital omega, Ω, somewhat distorted, and very unequally bright. Messier perceived only the bright [eastern] branch of the nebula now in question, without any of the attached convolutions which were first noticed by my father. The chief peculiarities which I

* This article has in part appeared in the Popular Science Monthly; and this Journal is indebted to Messrs. Appleton & Co. for all but one of its excellent illustrations.

have observed it it are—1. The resolvable knot in the [eastern] portion of the bright branch, which is in a considerable degree, insulated from the surrounding nebula; strongly suggesting the idea of an absorption of the nebulous matter; and, 2. The much feebler and smaller knot at the [northwestern] end of the same branch, where the nebula makes a sudden bend at an acute angle. With a view to a more exact representation of this curious nebula, I have at different times, taken micrometrical measures of the relative places of the stars in and near it, by which, when laid down as in a chart, its limits may be traced and identified, as I hope soon to have better opportunity to do than its low situation in this latitude will permit."

S.



W. E.

N.

Fig. 1.* HERSCHEL 1833.

From *Ast. Obs. at the Cape of Good Hope*:—After explaining that his first figure is far from accurate Herschel says:—

"In particular the large horseshoe shaped arc . . . is there represented as too much elongated in a vertical direction and as bearing altogether too large a proportion to [the eastern] streak and to the total magnitude of the object. The nebulous diffusion, too, at the [western] end of that arc, forming the [western] angle and base-line of the capital Greek omega (Ω), to which the general figure of the nebula has been likened, is now so little conspicuous as to induce a suspicion that some real change may have taken place in the relative brightness of this portion compared with the rest of the nebula; seeing that a figure of it made on June 25, 1837, expresses no such diffusion, but represents the arc as breaking off before it even attains fully to the group of small stars at

* For the use of the cuts which are given with this article, I am indebted to the courtesy of Dr. Youmans, Editor of the Popular Science Monthly.

the [western] angle of the Omega. . . . Under these circumstances the arguments for a real change in the nebula might seem to have considerable weight. Nevertheless, they are weakened or destroyed by a contrary testimony entitled to much reliance. Mr. Mason, a young and ardent astronomer, ... whose premature death is the more to be regretted, as he was, so far as I am aware, the only other recent observer who has given himself with the assiduity which the subject requires to the exact delineation of nebulæ, and whose figures I find at all satisfactory, expressly states that *both* the nebulous knots were well seen by himself and his coadjutor Mr. Smith on August 1, 1839, i. e., two years subsequent to the date of my last drawing. Neither Mr. Mason, however, nor any other observer, appears to have had the least suspicion of the existence of the fainter horseshoe arc attached to the [eastern] extremity of Messier's streak. Dr. Lamont has given a figure of this nebula, accompanied by a description. In this figure [our Fig. 3], the nebulous diffusion at the [western] angle and along the [western] base line of the Omega is represented as very conspicuous; indeed, much more so than I can persuade myself it was his intention it should appear."

S.

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Fig. 2. HERSCHEL 1837.

Herschel's Star-positions obtained in 1837 are given in Table II.

From Lamont's observations, *band* xvii, *Annalen der K. Sternwarte bei München*, p. 332 *et seq.*, I extract the following:—with regard to Sir John Herschel's drawing in the Cape of Good Hope Observations he says " . . . . bei mehreren Sternen scheint . . . . die Abweichung so gross, dass erst durch künftige Beobachtung entschieden werden muss, ob Aenderungen vorkommen, oder ob die Unterschiede in den Messungen ihren Grund haben."

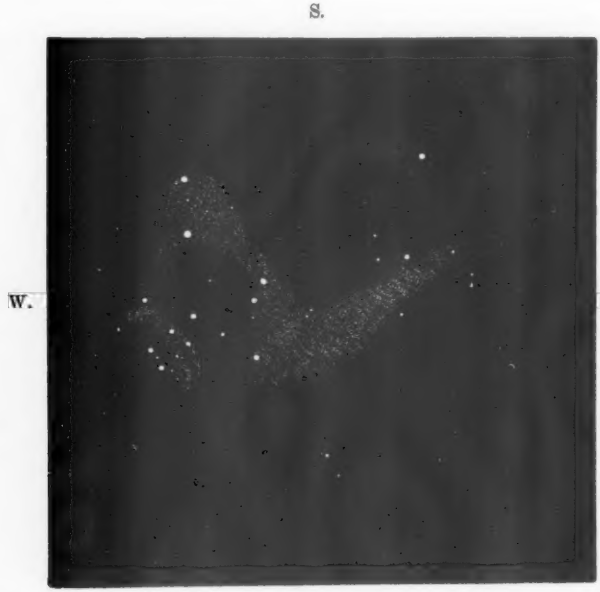

Fig. 3. LAMONT 1837.

Lamont's measures are mostly of position angle, and all of these which are directly comparable with Lassell's measures I have placed in Table III. We find two important notes on the physical aspects of the nebula as follows:—"Im Nebel kommt ein Knoten vor, den Sir J. Herschel als auflösbar betrachtet, während ich von Auflösbarkeit keine Andeutung bemerken konnte. Die Länge des Nebels-Knotens schätzte ich = Distanz (2) — (28) [Lassell's nomenclature] und die Breite=½ Distanz (2)—(7). An 2 August [1837] fiel mir eine Stelle zwischen (2) und (40) auf, wo ich einen

verschwindend kleinen Stern oder ein Häuflein solcher Sterne wahrzunehmen glaubte."

In regard to the credence due to Lamont's sketch the following sentence is important (*op. cit.* p. 305): "Was die . . . beigefügten Zeichnungen betrifft, so sind sie nur als Skizzen zu betrachten, welche blos den Zweck haben, die Messungsresultate verständlich zu machen."

S.

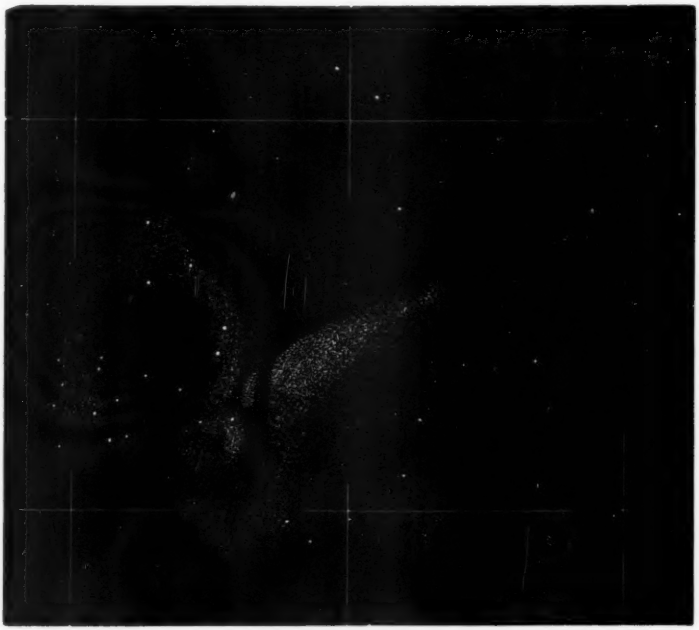

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Fig. 4. MASON and SMITH 1839.

From Mason's paper above cited:—

"*Things certain:*—1. The 'resolvable knot' mentioned by Herschel is isolated or nearly so, from the rest of the nebula.

2. The smaller knot is apparently not affected with this peculiarity.

3. Of the faint bend or loop [horseshoe] the *following* half is brighter than the *preceding*.

4. The bright branch fades away gradually to the [east]; it is convex [towards the south.]

5. The external angle of the nebula stretches down from the star [8] (of Lassell's nomenclature; see our sketch map, figure

8) towards the *n. p.* much farther than in Herschel's drawing." (our fig. 1.)

"*Nearly certain*:—1. The bright branch is more definitely bounded on its southern side than upon the northern. [??]

2. The 'resolvable knot' of Herschel has either a second nucleus or involves a faint star in its [south] margin."

"*Strongly suspected*:—5. Just [south] of star [2] is a portion a little brighter than the rest of the bend."

Mason's star positions are given in Table I.

Lassell gives no description of the nebula, and we extract only his measures of the co-ordinates of eleven of the brightest stars, which are contained in Table IV, and which we shall use as standard positions to which all others are to be referred.

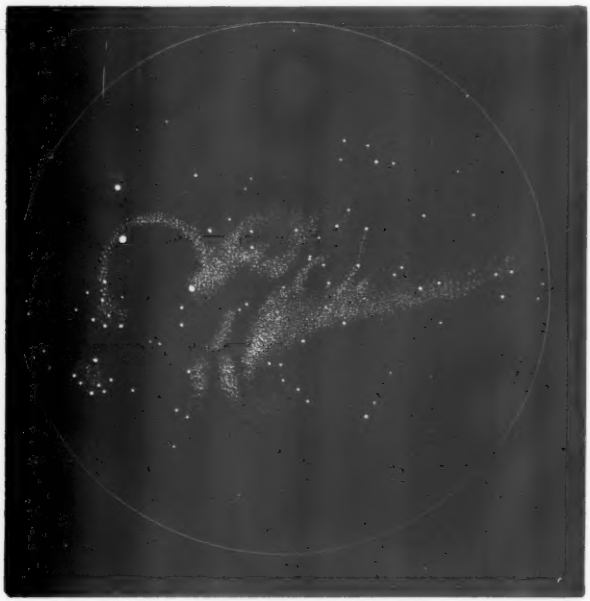


Fig. 5. LASSELL 1862.

We give Lassell's figure above, remarking that it was constructed, as indeed all the preceding ones have been, by first measuring the relative position of the brighter stars, then inserting by careful eye-estimates the fainter ones, and finally by drawing among these stars, guided by their configurations, the details of the nebula itself.

In Huggins' paper already cited (p. 385) we find the following:—

"Lord Oxmantown informs me that in the observations of this nebula at Birr Castle, there is no mention of resolvability; and that 'the central part to the right [east?] of star α [No. 2?] consists of bunches or patches of bright nebulosity with fainter nebulosity intervening.' The spectrum of this nebula indicates that it possesses a gaseous constitution.

One bright line only was seen, occupying in the spectrum apparently the same position as the brightest of the lines of nitrogen. When the slit was made as narrow as the intensity of the light would permit, this bright line was not so well defined as the corresponding line in some of the other nebulæ under similar conditions of the slit, but remained nebulous at the edges.

When the brightest portion of the nebula containing the nucleus or 'bright knot' was brought upon the slit, in addition to the bright line a faint narrow continuous spectrum was seen. The bright knot appeared in my telescope smaller and more condensed than it is represented in the drawings of Sir John Herschel."

A very rapid method of drawing nebulæ, is the following: it yields to the first in the accuracy of the positions of the stars, but it is probably even superior to it in facilities for the correct representation of the nebula and stars considered as one mass. A piece of glass ruled carefully into squares (see figs. 6 and 7) and this is placed in the focus of the eyepiece so as to be plainly visible; the telescope is then directed upon the nebula, and a clock-work motion is applied to the telescope so that it follows the nebula accurately. Some one of the brighter stars is chosen, and it is kept by means of the clock-work accurately in the corner of one of the squares. A piece of paper ruled into squares similar to those of the glass reticle is provided, and on it the observer dots down the various stars in and about the nebula. This may take two, three or four nights, according to circumstances, but in all cases it requires much less time than the micrometric measurements of the brighter stars and the troublesome allineations required to fix the positions of the smaller stars and it has the great advantage that the work can be done in a perfectly dark field of view, whereas the micrometric measures demand the use of illuminated wires at least. After the stars are inserted, the principal lines of the nebula are put in, not only by the star groups, but also by the squares themselves. For my own use I have had constructed two reticles: one ruled in squares like those seen in figs. 6 and 7, and another in which the heavy-lined large squares (each containing nine small squares, see fig. 6) are still present, but are subdi-

vided into small squares by lines parallel to their own diagonals. After making all the use possible of the first reticle, the second is put in, and an entirely new set of reference-lines is obtained, making an angle of 45° with the old set. This, of course, could be equally obtained by revolving the first reticle through an angle of 45°, but it is not quite so convenient.

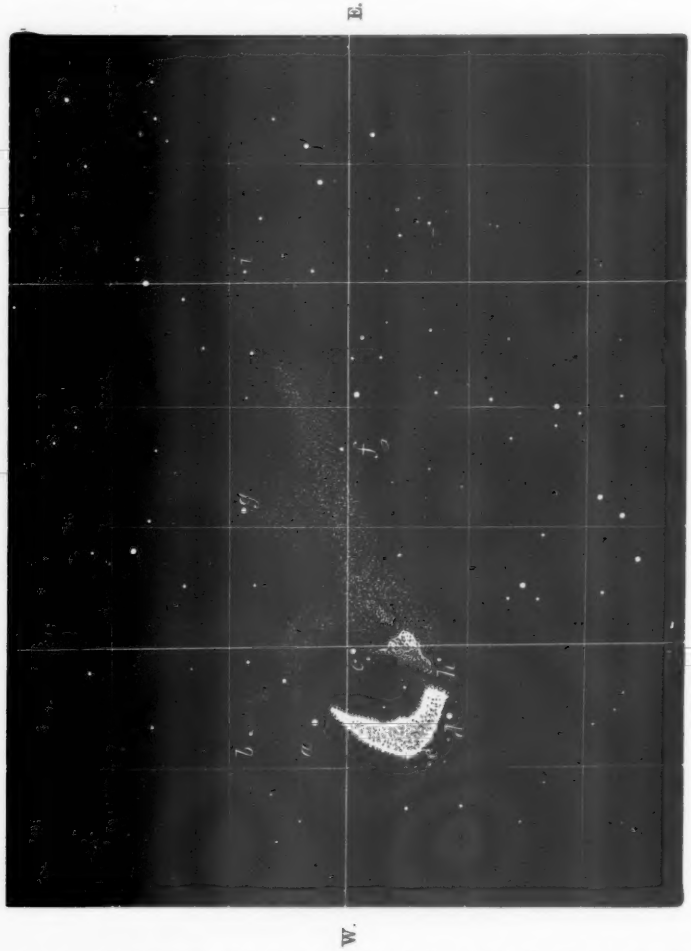


Fig. 6. Trouvelot 1875.

After the stars and the principal lines of the nebula are inserted a new and higher power eye-piece is used, and the drawing is concluded by means of this. Fig. 6 is an example

of a drawing of the Horseshoe Nebula made in this way by M. Trouvelot, of Cambridge, Massachusetts, with his 6½ inch refractor.*

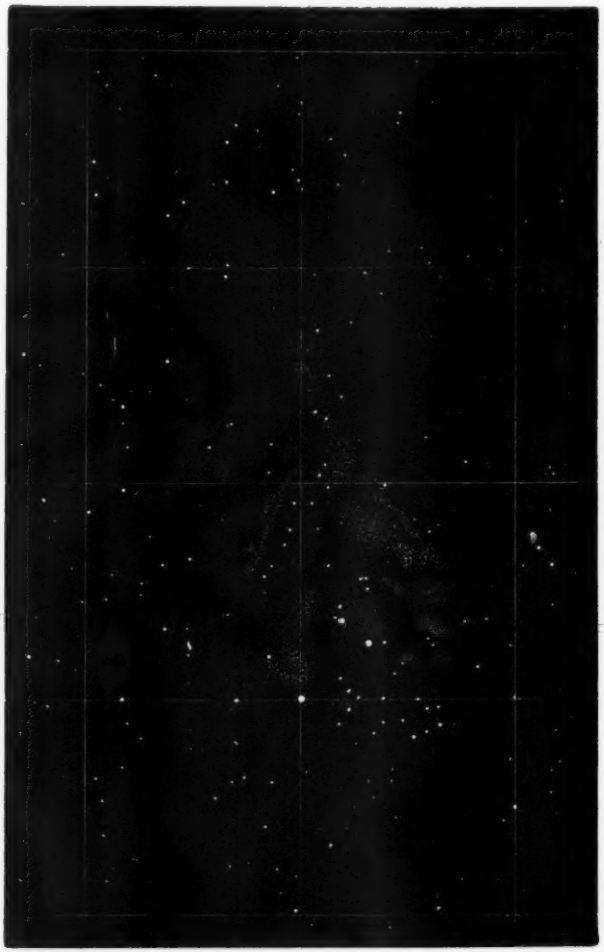


Fig. 7. Trouvelot and Holden 1875.

During the last summer M. Trouvelot was invited by the Superintendent of the United States Naval Observatory to visit

* That portion of the nebulosity within the horseshoe has been made far too bright by the engraver in this figure, but the shape is properly kept.

Washington for the purpose of making drawings of nebulæ, etc., by means of the twenty-six-inch Clark refractor. By the courtesy of Admiral Davis I am able to give a drawing of the Horseshoe Nebula as delineated by M. Trouvelot from observations made jointly by him and myself.

Pretty much the same method was adopted in this drawing as in fig. 6, but the vastly more complex structure of the nebula itself is what might have been expected from an increase of eighteen times in the light, over M. Trouvelot's six-inch telescope.

It may be said of the drawing from which fig. 7 was copied, that nothing is there laid down about which the slightest doubt is entertained; and although, in some respects, it was made in greater haste than is desirable, yet it is sufficiently accurate to found an argument on, for or against variation in the shape of any of the *brighter portions* of the nebula. The fainter portions of fig. 7 are too well defined and too bold, but it is, in general, a good representation.

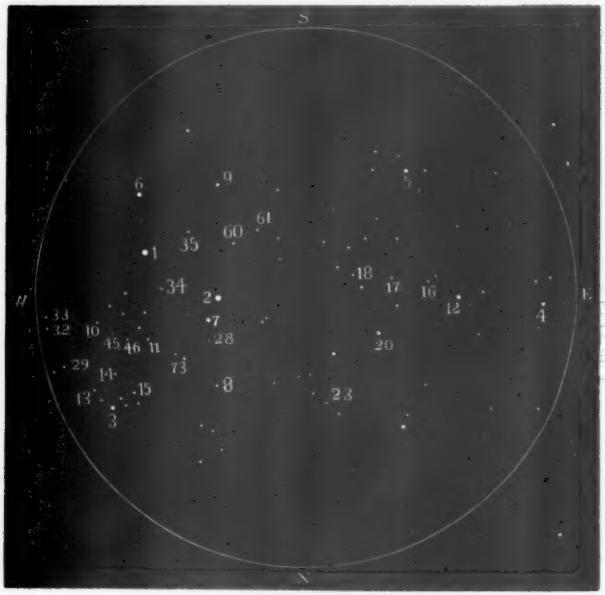


Fig. 8. Sketch-map of Stars (LASSELL).

For the purpose of studying this and other nebulæ, I have had the original drawings photographed *on a uniform scale and in such a way as to cause all the photographic prints to represent*

the nebulæ as they would appear in a refractor. It is only in this way that several drawings, made both by reflectors and refractors can be satisfactorily and minutely compared. The cuts of the present paper were reproduced from such photographic prints, and they are on a scale of one inch = 266″·2; in the present paper, however, all *conclusions* are drawn from an examination of the original engravings, although references are made to the cuts for convenience.

My own notes on the physical aspect of this nebula are as follows:—

"The brighter portions of this nebula give evidence of resolvability. In particular all the brighter parts of the "horseshoe," and of the long branch extending from star 8 to star 71, seem under intense looking, to be just ready to break into small stars. Many small points of light were put down both by myself and by M. Trouvelot, but it was soon found that such a task was endless and of far less importance than the correct delineation of the nebulosity. For nearly all the details of the drawing M. Trouvelot is responsible, as time did not allow of that careful and independent comparison which it is desirable should always be made; but it may be said briefly, that there are no conjectures laid down in the original. Everything is as it was seen. I confined my attention principally to the space limited by stars, 1, 6, 9, 61, 63, 70, 20, 8, 3, 10, on account of the evidence from older drawings that this portion has moved relatively to the stars; and I can vouch for its general accuracy.

This portion is sufficiently accurate to found an argument for or against variability upon. For example. I am sure that the brightest mass of nebulosity *follows* star No. 1, as M. Trouvelot has drawn it, and I am sure that the general direction of the dark channels between stars 7 and 53 is correct in the drawing."—[Sept. 21 to Oct. 2, 1875.]

Trouvelot's star co-ordinates were obtained graphically from the original sketch and are given in Table IV.

II. *Comparison of Star-positions.*

The only relative star-places completely determined which are of the highest accuracy are those of Lassell. "Eleven of the principal stars were measured and the remainder laid down by careful estimation, while some approximation to their proportionate magnitudes is preserved in the drawing. The numbers are generally, but not uniformly, in the descending order of magnitude." The star-positions of Lamont are of high accuracy, but unfortunately only angles of position were measured in most cases. Mason's work was done while he was an undergraduate at Yale College, with a telescope of his own construction mounted as an alt-azimuth, and in the intervals of his collegiate

duties, and although every endeavor was made to obtain high accuracy, and above all to determine the limits of error, yet his instrumental means were comparatively inadequate. He estimates the average error of his star-positions in this nebula to be about $1^s{\cdot}6$ in R. A. and $25''$ in δ (*see* pp. 192 and 193 of his memoir already quoted).

Most of Herschel's stars were inserted by allineations. The method chosen by M. Trouvelot and myself has already been noticed. It may be of interest to remark that the mean error of Trouvelot referred to Lassell is about $7''{\cdot}7$ in R. A. and $5''{\cdot}3$ in N. P. D. The larger residual in R. A. is due to imperfect running of the driving clock of the Equatorial. When this clock is in its usual good condition I believe that this error will not exceed $6''$, a quantity which is not appreciable in any drawing of a considerable nebula which can be put upon a quarto page.

TABLE I.—MASON'S STAR-POSITIONS.

Lassell's number.	Mason's number.	Mason's magnitude.	Mason's R. A. 1830·0.	Mason's δ 1830·0.	Remarks.
33?	1	14·15	18h 10m 28·9s	−16° 13′ 47″	When the identification of one of Mason's stars with one of Lassell's is at all doubtful a question-mark (?) is added in the first column.
32?	2	14.15	29·3	13 11	
13	4	13	32·9	12 24	
10	5	14	33·3	13 51	
3	6	12·13	34·74	11 45	
14	7	15	35 3	12 43	
15	8	15	36·5	11 50	
6	9	12	38·51	17 15	
11	10	15	38·5	13 23	Other stars can be identified but only so many are included as will suffice to determine the limits of the nebulosity. The same remarks apply to the following tables.
1	11	11	38·56	15 44·4	
73??	12	14·15	42·2	13 5	
35	13	14	43·3	16 15	
7	14	12·13	45·32	13 58·9	
28	15	16	46·0	13 30	
2	16	11	46·84	14 36·0	
8	17	14·15	10 47·3	12 24	
18?	22	16	11 1·0	15 21	
23?	24	14	6·1	10 57	
5	25	12	6·19	18 17	
17?	26	16	7·7	14 58	
20	27	14	8·3	12 15	
16?	28	16	11·1	14 31	
12	29	12	18 11 20·3	−16 14 4	

TABLE II.—HERSCHEL'S STAR-POSITIONS.

Lassell's number.	Herschel's number.	Herschel's magnitude.	ΔR.A. from 11 in arc.	ΔN.P.D. from 11 in arc.	Class.	Remarks.
13	2	12	−91″·5	−201″·6	3	In the column "Class" the numbers have the following signification: — 1. denotes that the differences of R. A. and N.P.D. were *measured:* 2. denotes that these differences were derived from alineations from known stars; 3. denotes that these differences were derived from the position of the star as laid down by the eye on the chart. Columns 4 and 5 have been deduced from the corresponding data given by Herschel, Obs. C. G. H. p. 9.
10	4	14	−61·5	− 82·6	2	
3	6	11	−54·0	−232·8	1	
15	9	15	−15·0	−198·0	3	
6	10	11	−13·5	+115·2	1, 2	
1	11	9	0·	0·	1	
11	13	13	+ 4·5	−122·4	2	
73 ??	15	13	+73·5	−158·4	2	
35	16	12	+96·0	+ 49·2	2	
8	17	13	+109·5	−201·6	2	
7	18	11	+109·5	−112·8	2	
28	19	15	+112·5	−151·2	2	
2	20	10	+123·0	− 66·0	1	
9	21	12	+129·0	+134·4	2	
5	31	11	+423·0	+134·4	2	
12	35	13	+528·0	− 86·4	2	

TABLE III.—COMPARISON OF LASSELL'S AND LAMONT'S STAR-POSITIONS.

Lassell's number.	Lamont's number.	1862. Lassell's pos. angle, from 2.	1837. Lamont's pos. angle, from 2.	Δp. Lassell − Lamont.	Remarks.
1	3	239·1°	238·3°	+0·8°	No. 1. Lassell's distance 133·1″; Lamont's 134·3″; Δ*s* = −1·2″.
3	15	314·5	314·0	+0·5	
5	28	124·7	125·0	−0·3	
7	2	342·4	341·3	+1·1	* Correcting Lamont's measure of Aug. 2 from 173° 0′ to 177° 0′: omitting it altogether, Lamont's angle becomes 357·8.
8	17	357·6	*357·4	+0·2	
10	10	279·8	279·4	+0·4	
11	8	299·1	299·6	−0·5	

TABLE IV.—STAR-POSITIONS OF LASSELL, MASON, HERSCHEL AND TROUVELOT.

The co-ordinates are measured from star 2 (Lassell).

No.	Herschel 1837.		Mason 1839.		Lassell 1862.		Trouvelot 1875.		Remarks.
	Δ*a*.	Δδ.	Δ*a*.	Δδ.	Δ*a*.	Δδ.	Δ*a*.	Δδ.	
1	−123·0″	+ 66·0″	−124·2″	+ 68·4″	−114·2″	+ 68·3″	−116·1″	+ 64·5″	N+, S−; E+, W−.
3	−177·0	−166·8	−181·5	−171·0	−162·9	−160·3	−163·4	−157·0	
4	----	----	----	----	+492·6	− 18·6	+473·0?	*− 8·6?	
5	+300·0	+200·4	+280·2	+221·0	+284·3	+196·8	+281·7	+187·0	
6	−136·5	+181·2	−125·0	+159·0	−120·7	+158·2	−124·7	+165·6	
7	− 13·5	− 46·8	− 22·8	− 37·1	− 12·3	− 38·8	− 30·1	− 43·0	* Some doubt as to identity.
8	− 13·5	−135·6	− 6·9	−132·0	− 5·9	−137·8	− 17·2	−137·6	
9	+ 6·0	+200·4	----	----	+ 4·6	+177·5	+ 10·8	+178·4	
10	−184·5	− 15·6	−203·1	− 45·0	−189·8	− 32·7	−187·0	− 21·5	
11	−118·5	− 56·4	−125·1	− 73·0	−113·3	− 63·0	−118·2	− 64·5	
12	+405·0	− 20·4	+351·9	− 32·0	+365·9	− 12·8	+352·6	− 6·4	

TABLE V.—COMPARISON OF LASSELL, MASON, HERSCHEL AND TROUVELOT.

No.	Lassell—Herschel,		Lassell—Mason,		Lassell—Trouvelot.		Remarks.
	$\Delta\alpha$.	$\Delta\delta$.	$\Delta\alpha$.	$\Delta\delta$.	$\Delta\alpha$.	$\Delta\delta$.	
1	8″·8†	2″·3†	10″·0	0″·1	1″·9	3″·8	* Some doubt as to identity.
3	14·1†	6·5†	18·6	10·7	0·5	3·3	Those of Herschel's stars whose position was micrometrically determined are marked †, the rest are estimated.
4	----	----	----	----	19·6*	10·0*	
5	15·7	3·6	4·1	24·2	2·6	9·8	
6	15·8†	23·0	4·3	0·8	4·0	7·4	
7	1·2	8·0†	10·5	1·7	17·8	4·2	It will be noted that Mason's residuals are quite within his limits of error.
8	7·6	2·2	1·0	5·8	11·3	0·2	
9	1·4	22·9	----	----	6·2	0·9	
10	5·3	17·1	13·3	12·3	2·8	11·2	
11	5·2	6·6	11·8	10·0	4·9	1·5	
12	39·1	7·6	14·0	19·2	13·3	6·4	

It may be seen from table III that the relative positions of the principal stars of this group are the same during the period of observation. Precession will cause changes of relative position far less than the errors of observation.

III. *Comparison of Star-magnitudes.*

It will be remembered that Lassell's numbers represent generally the order of brightness of the stars. Mason's magnitudes were reduced by himself so as to correspond to those of Herschel, and this was done in his own thorough way, by comparing his estimates of the brightness of stars in *Nebula Cygni*, with those previously given by Herschel. Lamont and Trouvelot give no magnitudes.

Table VI contains most of the information available on this subject.

TABLE VI.—COMPARISON OF STAR-MAGNITUDES.

Lassell's number,	1	2	3	5	6	7	8	10	11	12	13	15	28	35	73 ??
Herschel's magnitude,	9	10	11	11	11	11	13	14	13	13	12	15	15	12	13
Mason's magnitude,	11	11	12·13	12	12	12·13	14·15	14	15	12	13	15	16	14	14·15

From this we see that the order of magnitude is as follows:

Lassell,	1,	2,	3,	5,	6,	7,	8,	10,	11,	12,	13,	15,	28,	35,	73;
Herschel,	1,	2,	3,	5,	6,	7,	13,	35,	8,	11,	12,	73,	10,	15,	28;
Mason,	1,	2,	5,	6,	12,	3,	7,	13,	10,	35,	8,	73,	11,	15,	28.

A *suspicion* of variability exists as to stars 12, 13, 10, 35, 8, 73, 11, 15,* 28, but 35, 8, 15 and 73 are the only cases in which a *probability* of variability exists and even in these cases it is slight. If my identification of Lassell's 73 on the other drawings is correct, there is a mistake in his magnitude. A tolerably bright star is very near its place.

* See p. 359.

IV. *Examination of the Question as to the Motion of the Nebula relative to the Stars.*

It will be remembered that the seven drawings of this nebula which we possess were made in the years 1833, 1837, 1839, 1862 and 1875 quite independently, by different observers and different telescopes. It is evident that in cases where these different drawings *agree*, there can be no doubt as to the existence of the feature delineated. The non-existence of any prominent feature not given is probable, although not certain. To examine the question proposed at the head of this section, it will be advantageous to divide the drawings into three groups, the *first* consisting of all figures made before 1840 (Herschel's, Lamont's, Mason's), the *second*, of Lassell's fine delineation, which is entitled to very great weight, and the *third*, of the two drawings made by M. Trouvelot, one at Cambridge and the other at Washington. It is well to recall the fact that Herschel's two figures were made with his 20-foot reflector of 18½ inches aperture; Lamont's with the Munich refractor of 11 inches; Mason's with a 14-foot reflector of 12 inches; Lassell's with his 4-foot reflector; M. Trouvelot's first drawing with a 6½ inch Merz refractor, and the Naval Observatory drawing with the very perfect Clark refractor of 26 inches.

To prove the existence of a change it is necessary and sufficient to show that a prominent feature which the first group of drawings gives, is in a different position relative to the stars in Lassell's drawing and that the motion thus shown is confirmed and continued by the two figures of 1875, much greater weight being given to the work of the larger instrument in 1875. It must be remembered that with two instruments of *equal light*, hardly more discrepancy in the positions of the *brighter* portions of the nebula is to be expected than in the star-positions, for these positions are determined by the stars themselves and can be assigned with almost no error, in a nebula which contains so many stars as the one under consideration. The fainter portions may vary greatly from the smaller to the larger instruments. No relative numerical weight can be assigned to the various drawings, even if it were desirable to do this, but it may be remarked that Mason's, Herschel's (1837), Lassell's and that of the Naval Observatory are of the greatest authority. Herschel's first drawing, he himself does not consider comparable in accuracy to his second: Lamont's is of great weight as to the relative star-positions, but was not intended as anything more than a "sketch," and Trouvelot's first figure while undoubtedly of high accuracy as far as his instrumental means were satisfactory, is yet not strictly comparable with the work of Herschel's and Lassell's reflectors, or to his own work with the Naval Observatory refractor.

In Table VII, I have thrown into a convenient form the evidence for or against a motion of the "horseshoe" with reference to its contained stars. It will be remembered that so far as our evidence goes (see Tables III and V) the relative position of the stars themselves has not changed; as the agreement of the careful measures of Lamont and Lassell (whose observations are separated by 25 years) is quite as good as can be expected. In Table V none of the residuals are greater than the limits of error supposed by the various observers to exist in their own work; and most of them are less. It is moreover, plain that if the star-positions had changed while the nebula also moved, even this fact would not effect the question as to whether the line joining two stars, say 10 and 11, was *inside* or *outside* of the nebulosity. It is therefore in this way that I have presented the evidence concerning the motion of the "horseshoe" relative to the principal stars. That is, I take a certain line, as that one joining stars No. 10 and 11 and terminated by them, and arranging the drawings chronologically, I enquire how this line is situated with regard to the nebula in the various delineations Is it all inside, or partly outside? If partly outside, what fraction of its length is outside? The single exception to this method is that of star 11, whose remarkable situation in the various drawings of the nebula first led me to suspect a change.

The number of *independent* proofs of the change, is not quite so great as the number of columns in Table VII, since most of the evidence rests upon the positions of stars 1, 34, 35, 2, 10, 11.

It will be seen that not only is the change progressive from group I to group II and from this to group III but that in general it is even progressive from drawings 1 to 7.

The exception to this general progression is fig. 6, made by M. Trouvelot with his 6½ telescope shortly before the drawing No. 7. It will be observed that in many particulars his description corresponds to that given by the figures 1 to 4; which might indicate that the differences observed are only such as might be expected from the employment of different telescopes by different observers. This explanation I do not believe to be the correct one, for the reason that, *first*, no explanation is thus attained of the large and consistent differences between the drawing of Lassell and that of the Naval Observatory; and *second*, that an examination of the position of the line of maximum brightness in the early figures, and in that made by M. Trouvelot at Cambridge, shows that so far as the evidence goes, *the line of maximum brightness* in the western half of the horseshoe, is now further to the east than it was in 1834–9. It is evident that if the line of maximum brightness was plainly laid

TABLE VII.

Group.		Authority.	Star, or Line joining two Stars, under examination.							
			No. 11.	10–11.	10–14.	10–13.	10–3.	1–34.	2–35.	2–7.
I.	1.	Herschel 1833.	not inside on foll'g edge.	all inside.	all inside.	all inside.	all inside.	34 not laid down.	middle outside ends inside.	inside.
I.	2.	Herschel 1837.	outside.	E.$\frac{5}{8}$ outside.	all inside.	all inside.	all inside.	all outside.	inside.	inside.
I.	3.	Lamont 1837.	outside.	E.$\frac{11}{16}$ outside.	all inside.	inside.	inside.	N.$\frac{2}{3}$ outside.	all inside.	all inside.
I.	4.	Mason 1839.	outside.	E.$\frac{14}{16}$ outside.	all inside.	all inside.	all inside.	34 not laid down.	all inside.	all inside.
II.	5.	Lassell 1863.	inside on following edge.	all inside.	N.$\frac{1}{6}$ outside, star 14 quite outside.	nearly all outside.	N.$\frac{3}{6}$ inside.	all outside.	at least $\frac{1}{2}$ outside.	all inside.
III.	6.	Trouvelot 1875.	not inside near following edge.	nearly all inside.	inside.	all inside.	all inside.	N.$\frac{2}{3}$ outside.	middle outside ends inside.	outside?
III.	7.	Trouvelot and Holden 1875.	inside on following edge.	W.$\frac{1}{6}$ outside?	S.$\frac{1}{6}$ outside, star 14 quite inside.	nearly all outside.	N.$\frac{1}{3}$ outside.	all inside.	all inside.	inside on preceding edge.

Abbreviations used in above Table. N.= north; S.= south; E.= east; W.= west.
For a *star:* (see column 1) inside *or* outside = quite inside *or* quite outside of the nebulosity.
For a *line joining two stars:* inside *or* outside is not so expressive of *certainty* as *all* inside *or* outside.

down by each observer no difficulty would be found in making an exact comparison, and it will be found from an examination of the original engravings that the tracing of such a line on them is a matter of some difficulty. Still, it is believed that sufficient definiteness can be attained to show that on the whole Trouvelot's Cambridge drawing is consistent with the conclusion above given. In particular, his star No. 1 is not at all on the *following* edge of the nebulosity, but well within it, towards the *preceding* side, thus totally differing from the appearances laid down by all earlier drawings. Again, he represents the space *within* the horseshoe and *north-following* star No. 1, to be largely filled with nebulosity, quite consistently with the Naval Observatory drawing, and utterly different from the drawing of Lassell (see Fig. 6). This fact is of great importance, since, if the nebulosity *followed* star No. 1, in 1862, Lassell would have so represented it (as he did not) and as Trouvelot has so drawn it, it is plain that an important change must have occurred to render it possible for a six-inch aperture to show nebulosity in 1875, in a space perfectly void of nebulosity to Lassell's great reflector in 1862. *On the whole, then, these drawings show that the western end of this nebula has moved relatively to its contained stars from* 1833 *to* 1862, *and again from* 1862 *to* 1875, *and always in the same direction.*

I conceive that this is the best conclusion that can be drawn from the *ensemble* of the drawings. If we confine our attention to the three best ones, viz: Herschel's (1837), Lassell's (1862), and that of the Naval Observatory (1875), this conclusion comes out with greater distinctness. There is only one important feature in these three drawings which does not strictly agree with this supposition, namely that star No. 1 is in the same position with reference to the nebulosity in the first two of these which were made at an interval of twenty-five years and that they both differ from the last drawing made thirteen years after Lassell's. In every other respect the agreement is strictly with the above conclusion, and however much weight I might have been inclined to give to this disagreement, if the only data were those of the drawings, I cannot regard it as final in the light of a most careful examination of the nebula on the very fine night of March 21, 1876, when the various drawings were compared with the heavens. I add from the observing books a literal copy of my recorded observations on that occasion.

Extract from Observing-Book.

"1876. March 21. 16^h–17^h. Observer HOLDEN, Recorder, D. P. TODD.

Omega–Nebula. R. A. $18^h\ 12^m$ N. P. D. 106°·2. Magnifying power 175.

Star No. 1 brighter, but not much than 2. It *precedes* $\frac{9}{10}$ of the nebulosity of the *preceding* hook of the horseshoe. The line joining 1 and 10 is barely inside the nebulosity. The line joining 10 and 3 is inside the nebulosity but not much. 11 is just on *following* edge of the nebulosity. 34 *follows* the *west* branch of horseshoe, about $\frac{1}{2}$ the distance 2–7 [this is a rough estimate only] and is clear of any nebulosity. The middle $\frac{1}{2}$ of the line 6–1 is in the dark. The line 6–35 is all in the nebula. 8, 73, 11 about the same magnitude; 73 is in faint nebulosity, on the *preceding* edge of it. Between 11 and 73 very faint nebulosity which joins these two stars. Line 3–13 is just inside the nebula.—Star No. 1 certainly *precedes* $\frac{9}{10}$ths of west branch of horseshoe. Line 1–34 has its *west* $\frac{7}{10}$ths in nebula. 34 seems to be in the dark. Certainly a connection across 11–73 more distinct than in Naval Observatory drawing —more definite.

Line 10–11 is all inside nebulosity.

" 1–36 " " "

" 10–13 runs through fainter nebulosity.

13, 14, 10 are on *following* side of a bay which is filled with very faint nebulosity. 43 brighter than 15. 44>42>15 but the inequality is not great. 15 is the faintest star of 43, 44, 42 and 15.

The dark space within the horseshoe and bounded by 2, 7, 73, 11 is elliptic; the largest diameter is perpendicular to the line 8–14, and the diameters are as 6 to 4. It seems more regular in shape than in Naval Observatory sketch. Line 1–36 crosses fainter part of nebula about $\frac{1}{3}$ of the way from 1 to 26 and nearer 1. *Preceding* the line 1–10 is a darker space about equal in width to the distance 1–6. *Preceding* that, the sky is nebulous for 10′ at least. [This requires confirmation.] There is a faint prolongation from 6 towards *south preceding*. The shape of Herschel's resolvable knot is correctly laid down by Trouvelot. Two stars at its southern point and a star at or near junction of the two prongs of this knot. Sky more transparent than I have ever seen it. Much annoyed by the forming of clouds."

It will be seen that it cannot be doubted that star No. 1 is *now* in a position relative to the nebulosity quite different from that laid down by Lassell in 1862. Further, all the earlier drawings except Herschel 1837, put star No. 1 well within the nebula, and hence we are forced to the conclusion that the west half of the horseshoe has moved with reference to *this* star. Trouvelot's drawing with his small telescope is the only one not showing a similar and consistent motion with reference to the group of stars 10, 11, 3, 13, 15, etc., and even here we find evidence of changes in the same direction from the earlier drawings and the conclusion of the motion of the west one-half of the horse-

shoe with reference to its contained stars acquires new weight. The eastern half of the horseshoe, or at least that portion of it north of stars 2 and 7 shows on the contrary no evidence of such motion.

The observed changes in the *drawings* may be best accounted for by supposing a bodily shifting of the whole of the horseshoe in a plane nearly perpendicular to the line of sight, and on a pivot situated somewhere in the region of star No. 8, though, of course, it is not supposed that this is a real explanation of the physical changes.

A careful study of the evidence relating to the *Messierian* streak indicates no motion with reference to the contained stars. Graphic methods lead to the angles of position of this portion given below, with which I have incorporated the results of measures by D'Arrest and Schoenfeld.

Herschel, 1833:	p=119°.	†Schoenfeld, 1862:	p=112°,
Herschel, 1837:	p=119°.	mean of two, 115°, 110°.	
Lamont, 1837:	p=113°?	Lassell, 1863: ?	
Mason, 1839:	p=115°.	Trouvelot, 1875:	p=113°.
*D'Arrest, 1855:	p=122°,	Naval Observatory, 1875:	p=119°.
mean of two, 128°, 116°.			

To sum up:—Tables III and V show that the stars have remained in their relative positions from 1837 to 1875; and a consideration of the drawings, whether taken as a whole or considered according to their relative importance, shows that the horseshoe has moved with reference to the stars while the *Messierian* streak has not moved, and that therefore *we have evidences of a change going on in this nebula.*

This may be a veritable change in the structure of the nebula itself such as was suspected by Schrœter, confirmed by Otto v. Struve and again confirmed by myself in the Nebula of Orion, or it may be the bodily shifting of the whole nebula in space in some plane inclined to the line of sight.

A remarkable instance of a proper motion of this latter kind is that of the *Trifid Nebula* G. C. 4355, which has moved since 1833 so that the remarkable triple-star which was then quite clear from the nebulosity in a dark space formed by the junction of the three dark channels, is now by the evidence of Lassell (1863) Winlock and Trouvelot (1874) and myself (1875) well involved, the motion being confirmed by Herschel's drawing at the Cape of Good Hope (1837) and Mason's of about the same date.

The importance of the theoretical conclusions as to the constitution and distance of the nebulæ, to be derived from the first well-authenticated instance of the variation in form of any one nebula, have seemed to me to justify the discussion of the

* Abhand. d. K. Sach. Ac. d. Wissenschaften, Bd. v.
† Ast. Beob. Mannheim. Zweite Abth., 1875.

imperfect evidence now existing in regard to the one under consideration; and it must be remembered that no matter how inadequate this evidence may at first sight appear to be, it is yet as full, minute and complete as that relating to any single nebula except that of Orion; and if the drawings here considered are not sufficient to prove a change or the absence of a change, we are reluctantly driven to the conclusion that the work done by astronomers in this direction has been largely wasted. I hope that the evidence here adduced may be deemed of sufficient importance to warrant the great expense of time and labor necessary to a detailed monographic study of this nebula, which may serve for future reference. There is probably no nebula visible in the northern hemisphere more worthy of such examination.

U. S. Naval Observatory, April, 1876.

ART. XLIII.—*Brief Contributions from the Physical Laboratory of Harvard College.* No. XVIII.—*On the effect of thin plates of Iron used as armatures for Electro Magnets, and a new form of Induction Coil;* by JOHN TROWBRIDGE, assistant Professor of Physics.

IN a paper presented to the American Academy of Arts and Sciences, April 13, 1875, I showed that the application of armatures to two straight electro-magnets, which formed the primary circuit of a Ruhmkorff coil more than doubled the strength of the induction current produced by breaking the primary circuit. When, however, the circuit of the secondary coil was not closed, and a spark was allowed to jump across the interval between its poles, the striking distance of the spark and its power to charge a condenser did not seem to be notably increased by the application of armatures to the electro-magnets of the primary circuit. My experiments at that time were made with solid iron cores; and I now resume these experiments with bundles of fine iron wires in place of the solid iron cores. The mechanical difficulty of making the ends of the bundle of fine iron wires constituting the cores plain surfaces was overcome by dipping them in melted solder and then filing the ends smooth. In this way I had no trouble in applying the armatures so that they should lie upon a plain surface. The resistance of each of the two induction coils covering the two straight electro-magnets was 6000 ohms; and that of each of the straight electro-magnets, ·34 of an ohm. The diameter of the bundles of fine iron wires constituting the cores was 5 cm. and the length of the electro-magnets 28 cm. Condensers of

various sizes were placed in the primary circuit. The results given in this paper were obtained by the use of a condenser of about one farad. The method of experimenting was to charge a condenser of one-third of a farad; and then to discharge this condenser through a galvanometer. If we express the quantity of electricity received by the condenser by Q, the electromotive force by E, and the capacity of the condenser by C, we have $Q=\frac{2nt}{\pi}\sin\frac{1}{2}\theta$, where n is the reduction factor of the galvanometer, t the time of vibration of the magnet, and θ the angle through which it swings under the effect of the change. Knowing the reduction factor of my galvanometer, I had thus the means of reducing my results to absolute measure. But I speedily found that the relative results obtained by the proportions

$$Q : Q' = \sin\tfrac{1}{2}\theta ; \sin\tfrac{1}{2}\theta' = E : E'$$

would present the points of this investigation in as clear a manner as if the results had been reduced to absolute magnetic measure. My first experiments were made with solid armatures.

Table I.

Without armatures. Tan θ.	With armatures. Tan θ'.
80	90
70	80
90	100
60	70
70	85
80	90
Mean, 75	86

Table II.

Without plates.	With plates.
80	400
70	380
90	370
60	400
70	370
80	400
Mean, 75	Mean, 386·6

In table I the numbers are the deflections of the reflecting galvanometer expressed in millimeters, and the distance of the scale from the magnet was one meter. In this case the gain by the use of the armatures was trifling, being only about fourteen per cent. These results were obtained by charging the condenser of one-third of a farad, by sparks one millimeter in length. On a closed secondary circuit, however, a gain of one hundred per cent was clearly seen in the strength of the induced currents produced by breaking the primary circuit. The question, how to make this increase in the strength of the induced current by the employment of armatures apparent on a broken secondary circuit, became an interesting one. It seemed at first as if the application of armatures, by maintaining the temporary magnetization of the iron cores would be detrimental rather than otherwise. I next tried the effect of bundles of thin iron plates, which were placed, as armatures, upon

both poles of the electro-magnet, thus making a magnet of a horse-shoe form. On charging the condenser, I found a very great increase in quantity, which was manifested by the swing of the galvanometer needle; the indicator being entirely off the scale.

Table II shows the results obtained by the use of iron plates one and one-quarter of an inch in thickness, twenty in number, constituting each armature.

Here a gain of four hundred per cent was manifested by the use of thin plates. The next step was to ascertain how many plates were necessary to obtain the maximum effect. The difficulty of obtaining plates of the same homogeneity, made it impossible to obtain smooth curves. To this difficulty was added that of breaking the primary circuit in a regular manner. If the results of Table III are plotted, it will be seen that the increase within small limits, is very nearly proportional to the number of thin plates, which were $\frac{1}{24}$ of an inch in thickness.

TABLE III.

No. of Plates.	Deflection of Galv.	No. of Plates.	Deflection of Galv.
1	11	6	15
2	12	7	15·5
3	13	8	16
4	13	9	18
5	14	10	18·5

On increasing the number of plates a point was reached where there was no additional effect. The best result was obtained when the mass of the armatures was approximately equal to that of the cores of the electro-magnets. Plates of $\frac{1}{32}$ of an inch were also used, but no advantage resulted in their employment over those of $\frac{1}{24}$ of an inch. It would seem that the thin plates followed the same law as that of the bundle of fine iron wires which constitute the cores of induction coils of the present day, and that only a moderate degree of discontinuity in the mass of iron submitted to magnetic influence is necessary to prevent the formation of currents of induction, which prolong the magnetism of the cores, and prevent the quick demagnetization necessary to produce intense currents of induction. The effect of insulating the thin plates with the dielectrics was also tried with no gain in effect. There appeared to be a slight gain by placing the plates edgewise on the poles of the magnets instead of allowing them to repose on their flat faces. This was doubtless due to better contact of the metallic surfaces.

Since the above results proved conclusively a very great gain in quality and electrometric force by the application of thin plates as armatures, I next measured the striking distance of the

spark. Table IV gives the results which are the mean of many trials.

TABLE IV.

Without armatures.	With armatures.
15 cm.	32 cm.
14	30
15	32
Mean, 14·5	31·3

A curious fact came to light in this connection; the lengthening of the spark was not shown when the spark leaped directly between the poles of the induction coil; the increase in quantity and electromotive force, was only made manifest to the eye by the employment of condensers in the secondary circuit. The results in Table IV were obtained by the employment of a leyden jar of large capacity. The increase in the quantity and electromotive force was not only shown by the increased length of the spark, but also by its increase in volume, and its louder snap. The spark consisted of a thick central bolt surrounded by curious thin, detached sparks. An attempt was made to measure the increase of light in the Geissler tubes by Vierodt's photometric apparatus, but it was found too inexact for this purpose; if, indeed there was any increase of light, which remains to be proved. I know of no results which bear upon the relation of the increase of light to the increase of electromotive force of the induction spark. Without condensers in the secondary circuit, however, the increased electromotive force of the spark was shown by its greater constancy in leaping over a given resistance of air.

Unless an instrument is desired for popular scientific lectures, length is not so much to be desired as quantity of electricity of a spark, and in this form of induction coil the gain is principally in quantity, although it is true that with the aid of leyden jars, the striking distance is increased one hundred per cent. The principal points of this paper can be thus summed up:

1. The application of thin plates of soft iron upon the poles of two straight electro-magnets, with bundles of fine iron wires for cores, increases the strength of the spark produced at the poles of the secondary coils surrounding the electro-magnets, four hundred per cent.

2. The length of the spark is increased one hundred per cent. This gain in length is only manifested by the employment of leyden jars of large capacity, which are connected with the secondary circuit.

3. Instead of distributing the fine wire of a Ruhmkorff coil upon a straight electro-magnet, as is done at present, this wire should be distributed equally upon two straight electro-magnets, whose poles should be provided with armatures of bundles of thin plates of soft iron.

ART. XLVI.—*Communications from the Laboratory of Williams College.* No. VI.—*Concerning Phosphorus Oxychloride;* by IRA REMSEN.

THE fact was recently established* that carbon monoxide, though it must be considered as an unsaturated compound, does not readily combine with the oxygen from ozone to form the saturated dioxide. Indeed it was impossible to discover any conditions under which such a combination takes place.

Although it is known that ozone does readily oxydize many substances, it seemed to me desirable to further test its action upon bodies which are generally recognized as unsaturated. For this purpose I have first employed phosphorus trichloride in the hope of obtaining the oxychloride, $POCl_3$. The method of formation of the oxychloride thus indicated would be interesting from more than one stand-point, as will be pointed out below.

It has already been shown by Brodie† that, when oxygen is passed into phosphorus trichloride at the boiling temperature of the latter, a partial transformation into the oxychloride takes place; and Michaelis‡ subsequently showed that this transformation or oxydation is exceedingly incomplete, even though the process be continued for two or three days. An analogous experiment has also been performed by Henry,§ who proved that, when sulphur and phosphorus trichloride are heated together in a sealed tube at 130°, the sulphochloride $PSCl_3$ is formed. It is plain that, in both of these experiments, one of the forces which opposes the combination is that which binds together the atoms of oxygen in the molecule of oxygen, and the atoms of sulphur in the molecule of sulphur; and hence, if we could employ free atoms of oxygen or sulphur instead of their molecules, we would expect the action to take place much more readily. In the case of sulphur, it is not possible, as far as we know at present, to obtain free atoms or unstable molecules which by their breaking up yield free atoms. In ozone, however, we have such an unstable molecule of oxygen. As we have seen in the experiment with carbon monoxide, above referred to, ozone does not always appear to furnish free atoms of oxygen when we might expect it to, and hence the formation of phosphorus oxychloride by the action of ozone could not be predicted with any certainty. Experiment proved, however, that the formation actually does take place with

* This Journal, vol. xi, p. 136.
† Odling's Handbook, i, 297.
‡ Gmelin-Kraut's Handbuch der Chemie, I, i, 391.
§ Berliner Berichte, ii, 638.

great ease, and that phosphorus oxychloride may be obtained in this way in any quantity.

Pure phosphorus terchloride boiling at 77° was placed in a flask. In the cork of the flask were three openings. In one of these was inserted a thermometer which dipped into the liquid; in another was a tube, leading from the ozone-generator, which served to conduct the ozone into the liquid; in the third was placed a tube which in turn was connected with an inverted Liebig's condenser, the latter serving to condense and return to the flask any vapors that might be formed. Oxygen, thoroughly dried by sulphuric acid and calcium chloride, was now passed through the tube which served as ozone-generator. At first I employed a Siemen's ozone-tube which was connected with an induction-coil. The action in this case was not marked, although I soon observed that the thermometer indicated a rise in the temperature of the trichloride. At the beginning of the operation the temperature of the liquid in the flask was the same as that of the air in the room, viz: 15°. In a short time it rose to 36° where it remained stationary, as long as ozone was conducted into the liquid. As soon as the current was stopped, the temperature began to fall and continued to fall gradually until the ordinary temperature was reached.

In about an hour the process was interrupted, and the liquid subjected to distillation. Its boiling point was markedly changed. Only a drop or two passed over before the thermometer indicated 80° and then the mercury rose gradually to 110° when all had passed over. About half the liquid boiled below 90°. This was again subjected to the action of ozone, but now instead of using Siemen's tube, as at first, Wright's tube connected with the Holtz electrical machine was used, and with much better results. The arrangement of the apparatus in this second experiment was the same as in the first. The temperature of the liquid in this case also began to rise as soon as the ozone was passed into it. In a few minutes the thermometer, which at the beginning of the operation indicated 15·5° stood at 44°, where it continued to stand with slight fluctuations during the entire process. At the surface of the liquid the increase in the temperature was so marked, that a portion was converted into vapor, which was returned to the flask by means of the condenser. In the flask, a few drops of a yellowish, resinous material made their appearance, principally at the end of the ozone delivery-tube. The quantity of this substance formed was so small, as to preclude the possibility of an investigation. On repeating the experiment subsequently, this substance always appeared as a product. Whatever it is, it seems to be somewhat volatile with the vapor of the oxychloride of phosphorus.

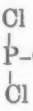
The passage of ozone into the flask was continued for about half an hour in the second experiment, and the product was then examined. About three quarters of the liquid now boiled above 100°, and it did not commence to boil below 85°. By the first distillation it was thus separated into two parts, one boiling below 100°, and the other boiling above 100°. The latter, without further treatment, was at once analyzed. A small quantity was weighed in a sealed bulb, and the bulb then broken under water. After decomposition, pure nitric acid was added and the solution then precipitated with silver nitrate.

0·251 grams of the substance gave 0·6842 grams AgCl= 0·1692 grams Cl.

This corresponds to 67·41 per cent of chlorine, while phosphorus oxychloride contains 69·37 per cent of chlorine and the trichloride 77·4 per cent chlorine. This analysis could hardly be expected to give more satisfactory numbers, as very little precaution was taken to separate the pure oxychloride from the mixture. It proves, however, that the liquid under examination contains markedly less chlorine than the trichloride with which we started, and nearly the same amount as the oxychloride which we would expect to be formed under the circumstances described. The deficit in chlorine may be accounted for by considering the yellow resinous material, above referred to, as being free from chlorine and being also somewhat volatile with the vapors of phosphorus oxychloride.

In addition to the above facts, it was found that the liquid was decomposed slowly by cold water—much less readily than the trichloride—and as a product of the decomposition with water, a large amount of phosphoric acid was formed. Taking then everything into consideration, there cannot be much doubt that, when ozone acts upon phosphorus trichloride, the latter is readily converted into the oxychloride.

The reaction is analogous to those referred to above, viz: the production of the oxychloride by the action of oxygen upon boiling trichloride, and that of the sulphochloride by the action of sulphur on the trichloride at 130°. Further, it is analogous to the reaction which gives rise to the formation of phosphorus perchloride by the action of chlorine upon the trichloride. The most natural thought that suggests itself is that all these bodies have a constitution similar to that of phosphorus perchloride, and that, in the above reactions, phosphorus passes from the triad to the pentad condition. Those who hold the view that the valence of an element is invariable are inclined to consider phosphorus oxychloride as having a structure essentially different from that of the perchloride, and they write its formula thus:

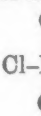


According to this, phosphorus is trivalent in the oxychloride, the same as in the trichloride. The grounds for this assumption are as follows:

1. The oxychloride can be converted into the form of vapor without undergoing decomposition, which shows that it cannot belong to the class of compounds known as molecular compounds, inasmuch as these latter are decomposed into simpler molecules by the action of heat. But, if it is not a molecular compound its structure must be similar to that of phosphorus trichloride, which is the type of the atomic compounds of phosphorus.

2. Thorpe* has recently shown that the specific volume of oxygen in phosphorus oxychloride is 7·89 and that of sulphur in the thiochloride 22·66. These values agree closely with those formerly found by Kopp for oxygen and sulphur which are united with another element with only one affinity each. From this the conclusion is drawn that in phosphorus oxychloride and thiosulphide, the oxygen and sulphur are united to phosphorus by only one affinity each, and hence that the structures of these bodies are represented by the formulas:

It may be remarked in regard to the former of these grounds that Würtz† has shown that phosphorus perchloride itself, the most decided representative of molecular compounds, may, under proper conditions, be converted into the form of vapor without undergoing decomposition, and hence there is no good reason for assuming that the perchloride differs from ordinary chemical compounds in any essential particular. If, however, the perchloride is a true chemical compound, an atomic in contradistinction from a molecular compound, then phosphorus is in it quinquivalent, while it is certainly trivalent in the trichloride. If, further, we once grant that phosphorus can and does act as a quinquivalent element, we would naturally suppose it to act so in the oxychloride, and hence to the latter would be given the formula,



* Berliner Berichte, viii, 326. † Comptes Rendus, lxxvi, 601.

This formula is more in accordance with known facts than the former one. We can much more readily understand how a compound of this formula may be produced by the action of water on phosphorus perchloride, than we could understand its formation if its formula were

$$\begin{matrix} & Cl & \\ & | & \\ P & -O- & Cl. \\ & | & \\ & Cl & \end{matrix}$$

Thus we have:

$$\begin{matrix} & Cl & & & & Cl & \\ & | & \diagup Cl & & & | & \\ Cl- & P & & + H^2O = & Cl- & P & =O+2HCl. \\ & | & \diagdown Cl & & & | & \\ & Cl & & & & Cl & \end{matrix}$$

Here the oxygen atom from the water simply takes the place of two chlorine atoms without any further disturbance of the molecule. But, if the formula $\begin{matrix} & Cl & \\ & | & \\ P & -O- & Cl \\ & | & \\ & Cl & \end{matrix}$ is correct, then it is plain that the reaction with water is much more complicated.

So too the formation of the oxychloride from the trichloride by the action of ozone is much more comprehensible, on the assumption that the reaction consists simply in the taking up of an atom of oxygen, without any accompanying displacement and subsequent binding of chlorine.

In regard to the experiments of Thorpe, it may be said that, if Kopp's principle is correct, i. e., if the specific volume of an atom is determined by the manner in which it is held in combination, and, if Thorpe's numbers are correct, then there can be no doubt that the conclusion drawn by him is also correct. While there is no reason for doubting the correctness of the numbers obtained by Thorpe, we may perhaps be justified in not accepting Kopp's principle as so firmly established, that we can employ it as a means of proving the correctness or incorrectness of formulas which seem to be well established by other means.

March, 1876.

ART. XLV.—*On additional species of Fossils from the Primordial of Troy and Lansingburgh, Rensselaer County, N. Y.;* by S. W. FORD.

IN a paper communicated to this Journal about a year ago (March, 1875) I gave a short account of the Primordial rocks in the neighborhood of Lansingburgh, N. Y., and of the finding of several species of fossils in a deposit of conglomerate lime-

stone occurring there. I had hoped to be able to devote a good deal of time to the further study of this field during the past season, but other matters prevented, and while I have made a number of additional observations upon the structure of the region, I am not, as yet, prepared to place them upon record.

From the conglomerate-limestone* I have, however, made collections on several different occasions and with very gratifying results. The following is a list of the species known to me from this deposit at the present time, all of which have been obtained from the rock in place: (1) *Olenellus asaphoides*, (2) *Conocephalites trilineatus*, (3) *Microdiscus speciosus*, (4) *Hyolithes Americanus*, (5) *H. impar*, (6) *Hyolithellus micans*,† (7) *Stenotheca rugosa*, (8) *Obolella desquamata*, (9) *O. nitida*. Of these 2, 4 and 9 were known from this deposit at the time of publication of my former paper. All of these species occur likewise in the Lower Potsdam limestones at Troy. This gives nine species in common to the two localities and is, I believe, conclusive as to the age of the conglomerate in question. I have no doubt but that, when further studied, this rock will furnish yet other species of the Troy series.

Fossils from the Primordial at Troy.—For a long time my examinations of the slates at Troy for fossils were unrewarded, notwithstanding I gave a good deal of attention to the subject. But on one occasion last summer I succeeded in finding several slabs containing undoubted plant remains. There appear to be two or three species. Of these, however, but one is represented in the collection by specimens sufficiently well preserved to admit of anything like a satisfactory determination. This is of the genus *Palæophycus*, and is, according to Mr. Billings, to whom I have lately submitted my specimens for comparison, perfectly identical with his *Palæophycus incipiens* (Pal. Fos., vol. i, p. 2), from rocks of the same age in Vermont and on the north shore of the Straits of Belle Isle in Labrador. The principal specimen in my collection is six inches long, nearly straight, of uniform width and without any evidences of branching. On the same slab there are several shorter fragments. This adds a

* This rock is of other than paleontological interest. I have recently ascertained that good typical specimens of it are susceptible of a fine polish. The limestone fragments of which it is principally composed are, for the most part, of a dark blue color, compact and of a flint-like fracture, and, in polished sections, contrast finely with the yellowish calcareo-arenaceous matrix in which they seem almost to float. Along with these are lighter colored, less coherent fragments in which the fossils mostly occur. It has been quarried to a considerable extent for building purposes, and appears to be a good durable stone. There is a bridge on the Troy and Boston R. R. in the village of Lansingburgh composed of it.

† Mr. C. F. McMurray of Lansingburgh, and a graduate of Yale College, who accompanied me on one of my excursions, has recently presented me with a specimen of an unusually large individual of this species, collected by him subsequently on the occasion of an independent visit made to the locality.

new class of fossils to the Troy fauna, and gives us, moreover, another example of a fossil species having an extensive geographical range.

It occurs in the coarse red-and-yellow-weathering slates of the Lower Potsdam group at Troy.

During the past season I paid a large number of visits to the first band of limestone met with in going eastward from Troy, and which, in a former paper, I have characterized as limestone band No. 1. (This Journal, Aug., 1873) As the result of this I succeeded in obtaining several species of fossils not previously known from this band, although known to occur in the other limestone beds of the Troy Primordial, and along with these a single head of a new and very pretty Trilobite of the genus *Microdiscus*. This I shall describe for the present as follows: Head, broadly rounded in front, nearly semi-oval in outline, greatest width at about the mid-length, slightly narrowed in passing backward from this point to the angles. Glabella conical, about two-thirds the length of the head, with two straight, moderately deep furrows extending all across, dividing the glabella in advance of the neck-furrow, into three parts of nearly equal length. Neck-furrow extending all across and deeper than the other glabellar furrows. The form of the neck segment cannot be clearly made out owing to the damaged condition of the specimen at this point. Dorsal furrows narrow, not deep, dying out toward the front of the glabella. Cheeks prominent, much swollen in the posterior third, without eyes or sutures. Marginal rim well defined all around, widest in front, with a conspicuously raised edge, inside of which there is a nearly flat or feebly concave space, and so bent upward in front as to give to the head on a side view a kind of slipper-like appearance On either side of the head, just inside of the raised marginal edge, there are three small tubercles situated within the limits formed by a line drawn across the head through the middle of the cheeks and another drawn parallel with it just in advance of the front of the glabella.

Greatest width of the head 1½ lines; length along the median line, including the neck-segment, the same. Differs from *Microdiscus* (*Agnostus*) *lobatus* Hall (Pal. N. Y., vol. i, p. 258, pl. lxvii, figs. 5 a–f), from the same locality, in its shorter and transversely furrowed glabella, its tuberculated margin, and in its general proportions.

For this species I propose the name *Microdiscus Meeki*, in honor of Mr. F. B. Meek, whose labors in the cause of science have so vastly contributed to advance our knowledge of American Paleontology.

Occurs in conglomerate limestone of the Lower Potsdam group at Troy.

Troy, N. Y., Jan. 15, 1876.

ART. XLVI.—*On a simple and very accurate method of tuning two Forks to unison;* by ROBERT SPICE, F.C.S.

THOUGH the optical method of tuning, of Lissajous, gives good results, I find that two forks thus tuned to unison, may be a *fraction* of a vibration *out*, without in *any way* disturbing the steadiness of the figure.

In the 2d edition (English) of Tyndall's "Sound," in lecture VII, the author says, "I divide this jar by a vertical diaphragm, and bring one of the forks over one of its halves, and the other fork over the other. The two semi-cylinders of air produce beats by their interference. On removing the diaphragm, the beats continue as loud as before, one half of the same column of air interfering with the other."

Dr. Tyndall does not, however, mention the fact, that precisely the same result would have been obtained if no diaphragm had been employed, yet this is so. When two unison forks are struck on the knee, (or by a piece of lead covered with leather,) and then held *together* over their proper resonant column, the following phenomena will be observed.

If there is a difference between their rates, of several vibrations, there will of course be rapid beats; if the forks are *very* nearly in tune, the beats will succeed each other at long intervals; further, when they are *almost* perfectly in tune, there will not be any beats properly so called, but after the sound of the forks has *nearly* died away, it will rise or swell out again *very slightly*, proving that there had been interference.

Finally, when the forks are absolutely alike, there will be a gradual decrease of sound, down to silence, without any reinforcement at any time.

I find that to carry out this tuning absolutely, both forks must be at the same temperature; consequently, after using a file on one of them, I place both forks in a vessel of water to equalize their temperatures, wipe them dry, and test them. To show the accuracy of this method I select the following example:

A pair of Ut^3 forks (256 vibrations) will sound over a column for about 135 seconds; suppose that the sound decreases up to the 100th second, and then begins to rise; obviously 100 seconds is the time of *half a beat*, or 200 seconds the beating time; that is to say, it will have been demonstrated that one of the forks gave $\frac{1}{200}$ of a vibration *per second* more than its fellow.

What has been said of the unison, applies to other intervals.

I have recently executed by this method, Ut_4, Ut_5, Ut_6 and Ut_7 forks for the physical cabinet of Columbia College.

230 Bridge Street, Brooklyn, Jan., 1876.

ART. XLVII.—*Silica of grasses and other plants carried up as Diatoms or other siliceous grains, and not in solution or as soluble silicates;* by Prof. P. B. WILSON.

MY attention was called, some time since, in the examination of the ash of plants obtained by slow incineration in a platinum crucible, to the fact that when the ash is treated with dilute acid, and evaporated to dryness on the water bath, it does not pass into the gelatinous condition prior to complete decomposition of the *hydrated* mass, as is the case with the silicates soluble in acid, or those decomposed with sodium and potassium carbonates. If, however, the ash, prior to the treatment with acid, is subjected to a high temperature, a combination of silicic acid with the alkalies, the alkaline earths, and the earths takes place, if all are present; then the silica separates in the gelatinous form and presents all of the chemical reactions of silicic acid obtained from the natural silicates. The silica obtained from ash by either of the processes indicated, on close examination, was observed to be entirely free from any combination, showing that it had been assimilated in the free state.

To demonstrate this theory, my friend G. I. Popplein, Esq., of this city, suggested the application of infusorial earth of the Richmond formation—found in large quantities on the western shore of the Chesapeake bay—to land sown in wheat. I have obtained straw from wheat so grown, and have found, after it has been treated with nitric acid, and the siliceous remains placed on the field of the microscope, that it consisted wholly of the siliceous shields of Diatomaceæ, the same as found in the infusorial earth, excepting that the larger discs in their perfect form were absent (*Actinocyclus Ehrenbergii* and *Actinoptychus undulatus*). My conclusions are that they, and there probably may be other forms, are too large to enter the root capillaries. During the coming summer I will attempt if possible to make micrometer measurements of both.

The discovery of Diatomaceæ in their original form in this wheat straw precludes the possibility of the infusorial earth having undergone any chemical change in the soil, either by forming chemical combination with the alkalies, or the earths, or by suffering physical disintegration from any catalytic action of any salts present in the soil

In the particles of silica placed upon the glass slide, when they were completely separated from each other, the outlines of the individual diatoms were sharply and distinctly defined. On the other hand, when the physical action of ebullition with nitric acid was not sufficient for the complete separation of the

particles of the epidermal shield, there was observed a marvelous interlacing of the various forms, showing that they were conveyed by the sap cells directly to the section of the plant where they were destined to complete its structure. I have examined several specimens of straw, taken at random in the market; the silica in each specimen consisted of plates, very thin, and truncated at the corners.

The result of these investigations shows the necessity of finely divided silica in the soil, so minute as to be capable of passing with facility through the sap cells; secondly, that simple or compound silicates are useless as fertilizing agents, either natural, or artificially prepared. We have no valid reason for forming any theory that vegetation can, through any known chemical law, separate the elements or their compounds from combinations so positive in their character.

In this case we have a practical result capable of being verified at any stage of growth of a plant, produced by the application of silica to the soil in the form of certain well defined microscopic organisms; for, finding these in the ash to the exclusion of other particles of silica, they seem to be more acceptable for the plant structure. Free silica is hence the only condition in which it can enter the plant.

I look upon this discovery as leading agricultural investigations in a new direction, and it must eventually change many of the views expressed and accepted by scientists.

Every precaution was used in having all the material thoroughly cleansed, with a view both for accuracy and for removing suspicions that these microscopic forms were the result of dust showers.

Washington University, Medical department, Baltimore, Md., February, 1876.

Art. XLVIII.—*The Conglomerate Series of West Virginia;* by William M. Fontaine.

[Concluded from page 284.]

Dr. Stevenson, in his "Notes on the Geology of West Virginia," (read before the Am. Phil. Soc., Feb. 5, 1875,) speaks as follows of the "Great Conglomerate" of Randolph county. "This rock forms the crest of Rich Mountain for nearly sixteen miles within the region examined. For the most part it is a coarse sandstone, loaded with pebbles from one third of an inch to two inches in diameter. Along the Staunton Pike it shows some layers of slightly micaceous and very compact sandstone near the bottom. Here it is greatly increased in thickness; near the northern line of the state it is barely 350 feet thick, but in Randolph county it is not less than 600." He further says, "On the

Staunton Pike, along the east slope of the mountain, there was seen midway in the conglomerate, what appeared to be the blossom of a coal bed. As I had observed no evidences of coal in the conglomerate northward from this locality, this exposure was studied with some care, but nothing definite could be ascertained. Six miles farther south, on the same side of the mountain, a small coal bed occupies this place on the property of Mr. Bradley. There it is three feet thick." Dr. Stevenson also points out the mistake made both by himself, and myself, in admitting the presence of coal in the conglomerate of Monongahela county.

Dr. Newberry has shown that the Sharon coals of Pennsylvania, which are in the reports of the first survey put under the conglomerate, are really of later age. There remains then no case where coals are found within the rock in its extension northward.* As is well known, the conglomerate in Pennsylvania north of this part of West Virginia, has thinned down to a homogeneous rock of 100 feet and less. We must then look for the north extremity of the special basin in which the expansion of this rock took place, somewhere in Randolph county. In farther confirmation of this, Dr. Stevenson mentions the curious fact that in that county the upper Umbral shales, at one point, thin out entirely, and the conglomerate is in contact with the limestone.

In Ohio, the reports of that State show that the conglomerate has become too thin to form a continuous stratum.

Proceeding southwest, from Ohio into Kentucky, we find the conglomerate series forming the west outcrop of the east Kentucky coal field, being the sub-conglomerate coals of that State. Mr. Joseph Lesley, (Proc. Am. Phil. Soc., No. 91,) in his account of this outcrop belt, shows that in that quarter the Umbral shales are entirely wanting, and that the coals under the conglomerate lie immediately on the sub-carboniferous limestone. He traces this outcrop from Carter county southwest to Clinton county, on the south border of the State. The thickening of the series in that direction shows plainly that his line of investigation diverged from the edge of the basin and approached nearer and nearer toward the central portions. He states that the series consists of two members, the upper one a conglomeratic sandstone, and the lower one a coal-bearing portion. The upper member thins in proceeding southwest, while the lower

* If Professor Tyson's section of the Cumberland basin be correct, then it is clear that northeast of Randolph Co., in Maryland, the conglomerate again has coal in its central portion. He gives on Savage River, above the Umbral shales, and including the so-called "Coal-Measure Conglomerate," a thickness of 451 feet. In this space he places three coal beds, two feet, two feet six inches, and two feet thick. The entire mass is begun and ended with massive sandstones, having a similar structure to the New River field.

member thickens at a more rapid rate. At Grayson, in Carter county, both together are only 90 feet thick, and the lowest coal is a mere streak formed between the base of the formation and the underlying limestone. Farther southwest, in Morgan county, the upper member is 150 feet thick, and the lower member only eight feet, and contains a twelve-inch bed of coal. In Estell county, the upper member measures 200 feet and the lower fifty feet, with the coal bed increased to twenty-seven inches. On the southern border of the State, the lower member increases to 225 feet, and contains two workable and three other thin beds of coal. The upper member does not now exceed eighty feet. This upper member is No. 21 of the Raleigh section.

Passing into Tennessee, we learn from Safford that the western outcrop presents the same essential features as in Kentucky. The red rocks of the Umbral are wanting, and the coal system rests on the sub-carboniferous limestone. But in Tennessee the thickness attained on the south border of Kentucky does not seem to be maintained in the counties immediately south of that point. Here also along the west outcrop in Fentress, White, and Franklin counties, the series is double, consisting of an upper sandstone and a lower coal-bearing portion. Of this latter Safford says, "It consists of shales and sandstones, the latter sometimes absent, and ranges from a few feet to about 200." It contains two, sometimes three, rarely more, seams of coal. These are often too thin for mining, but locally swell out and form valuable deposits, from two and a half to four or five feet in thickness."

This thinning out in the direction immediately south of Clinton county, Kentucky, seems to indicate that in Tennessee the west end of the basin sweeps around more to the south. Safford's sections show that these rocks increase in thickness from west to east with an increase of the sandstones, while the coals diminish greatly in the most easterly portions of the field; for while the west outcrop has the character above given, we find at the Ætna mines, a point farther east, a thickness of 563 feet, including the upper conglomerate, and at Lookout Mountain, the most easterly point of the sections given in the southern part of the field, we have 673 feet, composed mainly of coarse sandstone, with hardly any coal. This diminution of coal eastward agrees with the facts given by Professor J. P. Lesley for Wise, Russel, and Tazewell counties, Virginia.

One of the most striking points of difference between the strata shown on New River, West Virginia, and the west outcrop, is the disappearance in the latter of the thick deposits of the red Umbral shales underlying the conglomerate series in West Virginia. This is explained by the fact that these sediments are derived from the incoherent red shales, so abundant

in the upper Devonian of the Alleghany region on the east border of the basin. In this upper Devonian we find abundant red shales, which in physical character cannot be distinguished from those of the Umbral. None such are found in the Cincinnati anticlinal on the west border. It would also seem from what has been given above, that the quarter from which the greatest part of the sediment came, was the east, while the coals grew from the west.

If we may draw any conclusions from the data given above, we may believe that the coal-bearing rocks accompanying the conglomerate were formed in a comparatively restricted basin, which commenced in the northeast corner of Alabama, and extended as far northeast as Randolph County, West Virginia. Its deepest part was probably along a northeast line which passes east of the Cumberland Mountains, and crosses New River near the center of Raleigh County. The strata occupying the interval between the Devonian and the lowest of the "Lower Productive Coals" are on New River in this region at least 4,200 feet thick. It is highly probable that the formation of this deep narrow trough caused that intense strain in the crust of the earth which finally resulted in the production of that wonderful system of faults which is found on the east border of the coal-bearing strata described above, and which seems to be mainly developed along this border near the deepest part of the depression.

As to the character of the coal found on New River, in the series in question, it is a semi-bituminous coal, a fair example of which may be found in the seam mined and coked at Quinnimont. An analysis of this seam furnished me by Mr. Morris, shows the following: Carbon 75·89; vol. matter 18·19; ash 4·98; water ·74. The coke contains: Carbon 93·85; ash 6·15; sulphur ·23. This small amount of bituminous matter is noteworthy when we consider the undisturbed condition of the coal beds. This disturbance is no greater than that found in the highly bituminous coals of later age in other parts of the State. We must explain this loss of volatile matter in some other way than by mechanical action.

Plants.—There are only two horizons which have yielded me plants. These are the Quinnimont coal seam, or coal No. 9, and coal No. 5, or No. 14 of the Piney River section. At the locality which I shall give as horizon of coal 5, Quinnimont, this coal bed does not show, owing to the imperfect exposure, but the shales containing the plants occur at the horizon of coal 5.

I cannot pretend to have made anything like an exhaustive search for plants, even at these horizons. I made my explorations on foot, armed only with a small hammer and satchel as the implements for procuring and transporting specimens. On

the Raleigh road, and at the locality at Quinnimont, all my material was obtained from the weathered outcrop of the plant-bearing shales. In my second visit to the locality at Sewell Station I was in hopes of making large additions to my stock of the interesting plants found there on a former occasion. I was led to entertain this hope from the fact that in my previous visit I spent only an hour or two in the collection of the plants. But I found on my second visit that the impressions were restricted to a very thin layer in the roof, and that from the small amount of material on the "Dump" but little in addition could be obtained. The opening was inaccessible, being filled with water. It is an interesting fact regarding most of the plants found here, especially the *Megalopteris*, that they were seen nowhere else. The locality on the Raleigh road of the Piney River section, is a very promising one, affording a number of good specimens, in the weathered outcrop.

The following are the plants obtained from this series; some of them were procured in my first visit and were noticed in my former paper.

1. *Sphenopteris Hœninghausi* Brongt. Quite common in large and beautiful specimens with coal No. 5, Raleigh County.

2. *Calamites Rœmeri?* Göpp. Fragments resembling this calamite more closely than any other, were found with coal No. 9, at Sewell Station.

3. *Lepidodendron Selaginoides* Sternb. Good impressions of the bark and leafy branches, are not uncommon with coal No. 5, Raleigh County. I found associated with this plant very small leafy branches closely resembling the figures by Lesquereux, of *Lycopodites Meekii*. They are no doubt small branches of *S. Selaginoides*.

4. *Sphenopteris Adiantoides* Lindl. and Hutt. A single specimen but well marked, was found with coal 5, Raleigh County.

5. *Bornia radiata* Brongt. Found with coal 9, at Sewell Station, and coal 5, Raleigh County.

6. *Odontopteris gracillima* Newb. A single pinnule was found at Sewell Station with coal 9.

7. *Neuropteris, species?* Of this plant I have some detached pinnules, and one pinna with five pinnules, not enough for positive determination. It was obtained at Sewell Station from coal No. 9. The following features are shown in the specimens obtained: Fronds bipinnate; pinnules placed obliquely, and remotely; attached by the central portion of the base; subalternate, 2½ cm. long, 8 mm. wide, margin strongly repand, oblong lanceolate, acute, upper portion of the base rounded obliquely, lower portion forming a short round lobe, midrib slender, but strongly defined, diminishing in size, and near the end, splitting up into nervules, rather flexuous. Side nerves

closely placed, leaving the midrib at a very acute angle, strongly arched so as to meet the sides at a right angle and forking repeatedly.

This plant so far as can be gathered from the imperfect specimens obtained, is of the same type with the *Alethopteris obscura* of the Pennsylvania reports. Fig. 13 of these reports would give a good representation of it if the pinnules were separate to the base, more remote, and inserted on the rachis as above described. The nervation is the principal point of difference. It will be noted that this plant has many features in common with the Mesozoic *alethopterids*.

8. *Cordaites Robbii* Dawson? This plant is rather rare and occurs at Sewell Station with coal 9, and at Quinnimont at the horizon of coal 5.

9. *Alethopteris Serlii?* Brongt. This plant, which is the most abundant one in coal 9 at Sewell Station, differs in some points from *A. Serlii*. The pinnules are more slender, and are decurrent by their lower base which forms a narrow wing, while the upper portion of the base is obliquely cut away so as to cause the midrib to spring from the upper margin, which is barely reached by the decurrent portion of the pinnule next above. The pinnules are usually strongly recurved. In these points it resembles Dawson's *A. discrepans* of the Devonian. It may be a new species.

10. *Calamites cannæformis* Schloth. This is not rare in the slates over coal No. 9, at Quinnimont.

11. *Alethopteris grandifolia* Newb. This plant which is common at the horizon of coal 5 at Quinnimont, at first sight of the upper entire pinnules, resembles No. 9, but in its nervation, which more resembles that of *Neuropteris*, and in other points, it is very different, I have placed this under *Alethopteris grandifolia* from which it is somewhat different, for the same reason that I included No. 9 under *A. Serlii*, being unwilling, without more abundant material, to place these plants apart. The forms of No. 11 seem all to come from the upper part of the frond, and belong to the broad leaved variety of *A. grandifolia*, if they are identical with it. They represent the terminations of fronds or compound pinnæ, showing in their lower parts, pinnæ pinnately cut into pinnules, which become more and more united toward the summit of the frond or pinna; changing first to pinnules, with deeply undulated margins, and finally passing into pinnules with entire borders. These closely resemble the broad leaved variety of *A. grandifolia*, but are relatively narrower, and less united at the base. In their mode of insertion, they resemble to a certain extent No. 9, being somewhat cut away above and decurrent below. In No. 9 the nervation is that of *A. Serlii*, while in the plant in question it

resembles somewhat that of a *Neuropteris* in the fact that the side nerves spring obliquely from the midrib, fork two or three times and curve strongly to meet the margins. The nervation is like that of No. 7, but in the insertion of the pinnules by the entire base, in their decurrence, and other points, this is a true *Alethopteris.*

12. *Neuropteris Lindleyana* Sternb. *Var.* This beautiful *Neuropteris* is common at Sewell Station, where it forms the only plant found at the horizon of coal 5. It also occurs with this coal, in the Piney River section, on the Raleigh road. While in the main point it clearly resembles *N. Lindleyana*, figured in the Fossil Flora of Great Britain, as *N. Löschi*, there are some points of difference. Our plant has not the same degree of sharpness in the terminations of the upper simple pinnæ, and these are not so much narrowed at the base. Again the rounded pinnules of the lower compound pinnæ have a much more slender midrib than that indicated in the figure of the British plant. They are also more closely placed. In the greater bluntness of the upper simple pinnæ, and in their nearer approach to a heart-shaped base, this plant approaches nearer to *N. Loschi*, but it is very different, and may perhaps be best considered as a variety of *N. Lindleyana.*

13. *Neuropteris tenuifolia* Schloth. Found with coal 5 on the Raleigh road, apparently rare.

14. *Sphenopteris, species?* This plant was found with coal 5 on the Raleigh road. The fragments found do not enable me to determine it satisfactorily. It belongs to the Schimper's section, *Sphenopteris cheilanthides.* It is in some respects like *S. Dubuissonis*, but differs in others. The following features are shown in the fragments obtained: Pinnæ oval lanceolate, placed alternately at right angles on the rachis. Pinnules obliquely and alternately placed on the secondary rachis which at the base is narrowly winged and from which they diverge; oblong, narrowing considerably to the summit, and slightly so at the insertion of the base, where they are decurrent. The pinnules diminish rapidly in size from the base to the apex of the pinnæ. At the base they are one cm. long and four mm. wide. The pinnules of the base of the pinnæ are cut obliquely into three oval tooth-shaped lobes on a side, which are remotely placed, and diverge slightly from the midrib. In ascending, the number of the lobes and the depth of their incision diminishes until the pinnules become entire, when they are very small and mere lobes of the wing of the rachis, which at the extremity of the pinnæ is much widened. The plant seems to have leaflets of leather-like consistency; the nervation is obscure

15. *Sphenopteris, species?* This plant, which is not uncommon with coal 5 on the Raleigh road, has a strong resemblance to

Sphenopteris Newberryi, but shows some features not seen in the figure of that plant given in the Pennsylvania reports. From a study of the isolated fragments, in which form alone I could get it, the plant shows the following features: The pinnules of the lower pinnæ have the form of those similarly placed in *S. Newberryi*, but are proportionally narrower at the base, distinctly separate, and more obliquely placed. In ascending, the pinnules of the upper pinnæ are finally reduced to circular segments of the laminæ of the pinnæ, and now if seen apart would be taken to belong to a different plant. These upper pinnæ are placed obliquely and alternately. They are ovate lanceolate, 12 mm. long and 6 broad at base; having the general shape and mode of incision shown in *S. decipiens* of the Pennsylvania reports. But unlike that, the termination of the pinnæ is prolonged into an acute point. Proceeding still higher on the frond, these pinnæ are reduced to semicircular lobes of the broad wing of the rachis which now forms the entire lamina of the upper part of the frond or compound pinna. The nerves are to a great extent masked by the thick leathery character of the leaflets, but, so far as mode out, are as follows: In the lower distinct pinnules there is a strong midrib which disappears before reaching the extremity of the pinnule, and gives it at first sight the appearance of a *Pecopteris*. The side nerves spring very obliquely from the midrib, diverge very slowly from it, curving gently out to the margin, and fork once or twice, being quite distant from each other. In the rounded lobes of the upper pinnae, the nerves rise from the whole base of the lobe curving gently outward, and downward, while forking as before. Here the nervation resembles that of *S. dilatata* as figured in the Fossil Flora of Great Britain. The same nervation marks the extremity of the frond. The most characteristic feature is the rarity of the nerves, and if the plant should prove to be new, would justify the specific name *varinervis*.

16. *Hymenophyllites spinosus* Göpp.? Fragments were found on the Raleigh road with coal 5, of a plant showing the basal portion of several pinnæ, which seem to be identical with the above named plant. Not enough material was obtanied to identify it with certainty.

17. *Sphenopteris macilenta* Lindl. and Hutt. This plant seems to be abundant on the Raleigh road, associated with coal 5. Good specimens were obtained.

18. *Equisetites, species?* A single sheath, resembling that of an equisetites, was found on the Raleigh road with coal 5.

19. *Asterophyllites acicularis* Daws.? A specimen showing several whorls of leaves having the character of the above named plant, was obtained from coal 5 on the Raleigh road. Not enough is shown for positive identification.

20. *Trigonocarpon triloculare* Hildreth. A single nut was found at Sewell Station with coal 9. A nut of a different character from any figured or described to my knowledge, was found at the horizon of coal 5 at Quinnimont. It is perfectly smooth with no markings, is about 12 mm. long and 5 mm. wide. cylindrical in shape, and bluntly rounded at the ends, one of which is furnished with curved stem-like appendages, as if for attachment. Nuts are quite rare, only these two being found.

21. *Megalopteris Hartii* Andr. In my last visit to the plant locality at Sewell Station, which furnished me on my former visit the specimens of *Megalopteris*, and which is coal in 9, I procured a few additional specimens of this plant, among which, by comparison with the plates which Professor Andrews has had the kindness to send me, I recognized his *M. Hartii*. Of this plant I have one specimen having the ends of the two leaves at the summit of the frond, showing about six inches of their length. Another specimen shows the termination of a much smaller frond, with three leaves. Along with these leaves I find several of a small *Megalopteris* which may prove a different species although the nervation, so far as it can be made out in the obscure state of all the plants found here, seems to be very near that of *M. Hartii*. Of the small plant, no more than two leaves together have ever been found, and no specimen shows the point of junction of these. The small size seems to be a constant feature. Such leaves are about 6 cm. long and 1 cm. wide; they are narrowly elliptical in shape, with a rather more acute termination than that of *M. Hartii*. The midrib seems to have been large for a leaf of this size, and very prominent. It leaves a deep rectangular impression.

22. *Megalopteris, species?* This plant is the most common form found at Sewell Station. It differs from all the forms of Professor Andrews' plants figured in the decided acuteness of the leaves or pinnules; in which respect it is more like *M. Dawsoni*. From this latter plant it differs in the more decided elliptical outline of the leaves, the more rapid narrowing of the leaves toward their extremities, and most of all, in the nervation, which so far as can be made out, is near that of *M. Hartii*, being fine, from closely placed slender nerves, which fork near the base and again near their middle; apparently, higher up, than in *M. Hartii*. The nerves are nearly parallel in their course; and curve very slowly outward to meet the border of the leaf. I have one specimen which shows one entire leaflet, and the base of another, which diverges from the rachis at the base of the first, showing the ordinary alternate arrangement on a winged rachis, of the leaflets in plants of this genus. The entire leaflet of the specimen, is 14 cm. long, and 2½ to 3 cm. wide. It is strongly

narrowed toward the base, giving it an oblanceolate shape. Near the extremity, it is rapidly narrowed to an acute point. It is most probably a new species, and if so, might receive the specific name *Sewellensis.*

23. *Sphenopteris obtusiloba* Brongt. Found rarely at Sewell Station, with coal No. 9.

24. *Palæopteris Jacksoni* Schimp. *Cyclopteris Jacksoni* Daws. Only one or two small fragments of this plant, were found at Sewell Station with coal 9.

25. *Sphenophyllum antiquum* Daws. A small fragment only was found at Sewell Station with coal 9.

26. *Odontopteris Neuropteroides* Newb. Good specimens of this plant were obtained from the horizon of coal No 5 at Quinnimont, where with the variety of *Alethopteris grandifolia*, it forms the most abundant plant. Some pinnules show an obscure lobing not unlike some of the pinnules of *Sphenopteris Lesquereuxii.* Some scattered broad pinnules, with undulating borders, were found here which, from their appearance, would seem to have belonged to some part of this plant.

27. *Calamites approximatus* Schloth. Found at Sewell Station, with coal No. 9.

The plants above named, with the exception of the few got from Sewell Station previously, and mentioned in my former paper, were all obtained in my last visit to the New River region. As I stated before, this list can by no means be taken as exhaustive of the plants, even at the locality where they were gathered. In no case could I spend more than a couple of hours in collecting, and, having no tools, my collection was made by picking up fragments fallen from the disintegrated outcrop. This was the case with the coal on the Raleigh road, which furnished so many of the above specimens.

The following fossils were obtained from near the top of No. 1 of the transition beds at Quinnimont and consequently just from the base of the conglomerate series. They were kindly determined for me by Dr. J. J. Stevenson. He states that in most cases they were too badly preserved for specific determination.

Invertebrate fossils from the base of the Conglomerate Series at Quinnimont.

1. *Productus cora* D'Orb.
2. *Athyris* sp.
3. *Spirifera Leidyi* N. & P.
4. *Aviculopecten.*
5. *Lima.*
6. *Myalina.*
7. *Macrodon.*
8. *Lithophaga.*
9. *Chœnomya?*
10. *Fenestella.*

Of these Dr. Stevenson states that the *Macrodon* is a new species, which also occurs commonly in the middle portion of the

Umbral limestone in Monongalia Co., W. Va. He thinks that the *Myalina* and *Chœnomya* are new species. Also that the *Lithophaga* is so near that referred with doubt to *L. lingualis* of Phillips, by M. & W., that he cannot distinguish it, although this is a species of the St. Louis group.

I may state here that the *Palæopteris Jacksoni* of the Conglomerate series, is the typical plant, and very different from the plant found at Lewis Tunnel, and given in my previous paper as *P. Jacksoni*. I have additional specimens from Lewis Tunnel, which show without doubt that, as Professor Andrews has suggested, this latter is a new species.

It will be seen from the above, that the representatives of the Devonian flora of Canada are quite common in the Conglomerate Series. The uppermost strata of the Devonian in West Virginia are at least 3500 feet below coal 5; and still farther below coal 9, which affords the plants of most decided Devonian type. Besides, the forms of *Megalopteris*, the *Palæopteris*, and *Sphenophyllum*, we have probably *Asterophyllites acicularis*, and *Cordaites Robbii*, identical with the Devonian plants. The *Cordaites* has the nervation and termination of the leaves of *C. Robbii*, but I mark it doubtful, as I have no entire leaves. The *Sphenopteris adiantorides*, is a good deal like the plant figured as *Cyclopteris obtusa*, by Dawson in the Acadian Geology, although smaller. The plant marked doubtfully *Alethopteris Serlii*, is very near *A. discrepans*. The *Sphenopteris* allied to *S. Newberryi*, in its upper pinnæ shows the mode of lobing, and has something of the aspect of *S. marginata*.

It will be noted that along with these plants we have some of the forms found in coal No. 1 of Ohio. The upper pinnæ of the plant identified with *Sphenopteris macilenta* I cannot distinguish from Dawson's *Cyclopteris valida*. Besides these, we have plants first found in Felling Colliery, England, associated with the "Low Main coal seam."

ART. XLIX.—*Mineralogical Notes;* by EDWARD S. DANA. No. III.—*On new twins of Staurolite and Pyrrhotite.*

1. ON STAUROLITE CRYSTALS FROM FANNIN CO., GEORGIA.

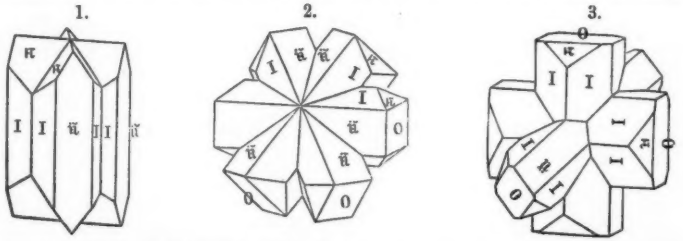
THROUGH the instrumentality of Prof. F. H. Bradley a large number of staurolite crystals have been recently received in New Haven, some of which show forms which are new and interesting. Prof. Bradley mentions two distinct localities, visited by him, which afford the staurolite in considerable quantities. The first is at Valley River, near Murphy, Cherokee Co., North Carolina. The crystals at this place are large

and coarse. They occur in a metamorphic rock which Prof. Bradley states belongs to the Cincinnati group.

The second locality is in Fannin Co., Georgia, 12 miles southeast of Ducktown, Tenn. The crystals obtained here are of quite uniform size, averaging an inch in length, and are very perfectly developed, the faces being smooth, though usually without polish. They occur in a soft mica schist, belonging geologically, according to the same authority, at the base of the Quebec Group. The rock is extensively decomposed so that the crystals are found abundantly loose on the surface of the ground. Large quantities of them may thus be picked up, of which perhaps one-tenth are perfect crystals. They are in general nearly free from the gangue.

The crystals are with rare exceptions twins. The most common twins are those well known in this species; that is, (*a*), those having the composition face $\frac{3}{2}$-$\breve{i}$, with the vertical axes nearly at right angles to each other; and (*b*), those having the composition-face $\frac{3}{2}$-$\breve{3}$, with the vertical axes crossing at a angle of about 60°. Under these two types there is a very wide diversity of form arising from the extension or partial suppression of various of the occurring planes. A very common feature in the twins of the first kind mentioned is the almost entire suppression of one pair of the macrodome planes 1-$\breve{i}$, opposite each other, with the corresponding extension of the other pair; this same kind of hemihedral development is also extended to the prismatic planes giving rise to forms of very oblique appearance.

Three new forms are shown in figures 1, 2 and 3. Figure 1 exhibits a new method of twinning not before observed in this



species, and making the third type of penetration twins peculiar to staurolite. The measured angle of the two brachypinacoids (i-$\breve{i}$) for the crystals in their twinning position is 70° 30′. This gives for the composition-face i-$\breve{3}$, which requires for the above angle 70° 18′. In this case the axis of revolution very nearly coincides with the plane i-$\frac{3}{2}$ and the i-$\breve{i}$, of the second individual is very nearly parallel to the prism I of the first. Attention has been called, by Prof. Dana, to the fact that if the

occurring prism on staurolite be made $i\text{-}\frac{3}{2}$, the twinning planes will be then planes of simple axial ratios in accordance with the usual law, namely $1\text{-}\breve{2}$ (instead of $\frac{3}{2}\text{-}\breve{2}$) and 1 (instead of $\frac{3}{2}\text{-}\breve{\frac{3}{2}}$). The new method of twinning here described would then have for its composition-face $i\text{-}\breve{2}$.

It has already been mentioned that when the twinning plane is $\frac{3}{2}\text{-}\breve{\frac{3}{2}}$ the vertical axes cut each other at an angle of about 60°. It would be expected from this fact that compound crystals of three individuals would be found, the entire circumference being thus divisible by six, and this has been the case. Figure 2 represents one of a considerable number of crystals of this description in which three interpenetrating individual crystals cut each other respectively at angles of 60° and 120°, and, being symmetrically developed, form thus a six-rayed star. Still another form is shown in figure 3; it is interesting as being a combination of two methods of twinning in the same compound crystal which has been rarely observed in any species. The vertical axis of two of the single crystals are at right angles to each other, and that of the third cuts each of the other two at an angle of 60°. This latter fact explains the occurrence of this form.

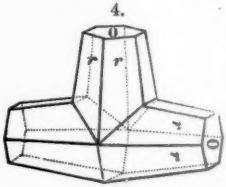
The crystals figured were from the cabinet of Professor Brush.

2. On a twin of Pyrrhotite.

The annexed figure (fig. 4) represents a remarkable crystal of pyrrhotite, which I have been enabled to examine through the kindness of Dr. Harrington of Montreal.

The crystal itself is somewhat more than three times the size of the cut, and is almost as symmetrically formed. The pyramidal planes (r) are uniformly deeply striated in a horizontal direction, parallel to the basal section; the faces are thus made quite uneven. Furthermore these same planes show a considerable number of minute longitudinal depressions, or etchings, parallel to the vertical axis. This is a prominent feature of all the pyramidal planes alike, thus confirming the accepted hexagonal nature of the species. The transverse crystal, as seen in the figure, is quite irregular, being made up of a group or bundle, of small crystals in parallel position; this is especially true of one of the extremities. These small crystals are some of them free from the striations alluded to and allow of exact measurement. The angle for $r \wedge r$ (basal) thus obtained is 163° ($O \wedge r = 98°30'$); this corresponds to the form $\frac{2}{3}$, which requires 162° 40′ ($O \wedge \frac{2}{3} = 98°\,20'$). The twinning plane

4.



the pyramid 1, by which the vertical axes of the two individuals are brought nearly at right angles to each other, since $O \wedge 1 = 135° 8'$. This combination of three individual crystals is analogous to the penetration-twins of staurolite, described above.

Dr. Harrington has kindly furnished some notes upon the occurrence and chemical composition of this pyrrhotite, which he allows me to append here.

On the composition and mode of occurrence of the pyrrhotite from Elizabethtown, Ontario; by B. J. HARRINGTON, Ph.D.

The deposit from which the crystal of pyrrhotite was obtained is economically important as being the source from which considerable quantities of pyrite have been derived for the manufacture of sulphuric acid. It occurs on the nineteenth lot of the second concession of Elizabethtown, Ontario, in rocks belonging to the Laurentian system, but its true character has not yet been ascertained. To the mineralogist it is especially interesting on account of the association of minerals which it affords. The minerals number a dozen, and probably more, species, being pyrite, pyrrhotite, magnetite, quartz, talc, labradorite? phlogopite? a compact black mineral probably allied to hisingerite, calcite, siderite, apatite and cacoxenite.

Of these the pyrite and calcite occur in greatest abundance. The former is generally massive, but is sometimes well crystallized—the most common form being a combination of the cube and octahedron. Perfect octahedrons with the axes more than two inches in length have been obtained, and mammillary groupings of cubical crystals with rounded faces occasionally occur. According to the determinations of Hunt and Macfarlane (Geol. of Can., 1863, p. 506, and Can. Nat., 1st Ser., vol. vii, p. 194) the pyrite contains about half a per cent of oxide of cobalt.

Calcite forms the principal gangue in which the other minerals are embedded. It is mostly massive, but is also found on the walls of cavities in the form of obtuse rhombohedral crystals, often curiously modified. It ranges from opaque to transparent, and varies much in color, being white, gray, fawn-colored and sometimes red. The compact black mineral alluded to above also frequently forms the gangue of the pyrites and with it is occasionally associated a triclinic feldspar (probably labradorite) showing a beautiful play of colors. Magnetite is rather common and sometimes occurs in the form of small irregular grains scattered through the calcite. The mineral which I take to be cacoxenite—the occurrence of which in

Canada has not before been noted—is found in beautiful little yellow tufts on the walls of cavities in the calcite, the tufts being often so close together as to form a velvety coating. It is generally associated with pyrite.

Quartz, mica, apatite, talc and siderite were noticed, but they did not form important constituents of the deposit. Pyrrhotite was common in portions of the deposit worked several years ago, but has become less so as the mining has advanced. It is sometimes massive, but more frequently well crystallized. In general it is embedded in calcite, but it has also been found in steatite. The following is an analysis of a crystal:

Iron,	60·560
Copper,	·145
Manganese,	·060
Nickel,	·112
Cobalt,	·111
Sulphur,	39·020
Silica,	·036
	100·044

Hardness between 3½ and 4. Specific gravity 4·622. Readily attracted by the magnet and possessing polarity; the opposite poles seem to be situated not at the extremities of the crystals but along the sides.

A few months ago a crystal of the pyrrhotite was sent to Professor J. Lawrence Smith, who was anxious to compare its composition with that of troilite. The results of his analysis sent to me by him are as follows:

Iron,	59·88
Sulphur,	39·24
Silica (gangue rock),	1·01
	100·13
Specific gravity,	4·642

ART. L.—*Researches on the Solid Carbon Compounds in Meteorites;* by J. LAWRENCE SMITH, Louisville, Ky.

IN the study of Meteorites, it is well known that, of all the simple and compound substances met with in these bodies, the carbon has received the least study and investigation. This has arisen principally from the limited amount of material at the command of the chemist,—a fact to be regretted, since if any one element more than another demands attention, and excites

wonder at the part it plays, either as an element or in its endless combinations with other substances, that element is carbon.

In its elementary condition we see it in crystals of exceeding hardness and brilliancy in the diamond, and also in irregular, nearly opaque masses that are not to be confounded with the diamond. Again, we have carbon in a soft, black, unctuous state, either in lustrous flaky crystals, or in fine-grained masses. It also occurs in the harsh and gritty form of coke, sometimes changed to an unctuous body approaching graphite in aspect, yet different physically as well as in some of its chemical relations. Deposits of anthracite furnish carbon in yet another form. Besides these, the results of decomposition of what are known as organic compounds give quite a list of different forms of carbon, made either by the incomplete combustion of hydrocarbons, or by passing through red-hot tubes the vapors of hydrocarbons, chloride of carbon, sulphide of carbon, etc., or by the decompositions of such substances as carbonic acid, carbides of boron, of iron, of manganese, etc.

These various forms of carbon have certain chemical differences, more or less marked, which differences have attracted the attention of chemists, although no one has studied them with much care or success except M. Berthelot, their investigation being difficult on account of the want of proper methods. M. Berthelot obtained his results by taking advantage of the singularly slow oxidizing action of a mixture of nitric acid and chlorate of potash on carbon, first pointed out by M. B. C. Brodie, in 1860,* in experiments on graphite, by which he produced for the first time what is known as graphitic oxide. He operated by this means on very many specimens of carbon, from the diamond to lamp-black, embracing a large variety of artificially prepared carbons, and discovered certainly six or eight more or less distinct chemical characteristics of these different carbons.† The physical differences of some of them are well known; among these differences none is more remarkable than that of their specific heats. Other bodies known as elements, as silicon and boron, oxygen, etc., take upon themselves different conditions called allotropic conditions,‡—a term applied to the isomeric conditions of simple bodies; but carbon differs from these, not only in exhibiting a most wonderful variety of allotropic conditions, but also in the phenomena coming under the head of isomerism, polymerism, and metamerism; so much

* Annalen der Chemie und Pharm., April, p. 6.

† The full detail of his researches is to be found in the Annales de Chimie et de Physique, IV, xix, 392, 1870 and xxx, 419, 1873.

‡ Notwithstanding the recent experiments of M. Weber, showing that under certain conditions, carbon, silicon, and boron are not exceptions to the law of Dulong and Petit, they still occupy a singular position in regard to specific heat.

so, that we are disposed to take this body away from the rank of a mere element, and call it a protean body that gives rise to substances of endless form and variety by combining with a very limited number of elements.

Additional interest attaches to carbon from the fact of its being regarded as belonging preëminently to the organic kingdom. In fact, some of the best observers and investigators assume that there is no such thing as mineral carbon among the rocks of our globe, and that wherever found, whether as diamond, graphite, or coal, it is a product derived from organic matter, in which it had first performed its part in the economy of nature.

A still more exciting interest has been felt in carbon since the new department of celestial chemistry has received the attention of scientists. And here we are not left for our knowledge of celestial carbon to the attenuated form of it which can be detected only by astronomical instruments; for masses of matter from other spheres reach our globe from time to time, bringing with them specimens of solid carbon for our investigation, and, at the same time, perplexing our minds with questions as to its mineral or organic origin, and as to the existence or not of life on other planets, and in other systems of planets.

Like the footprints of former life on the rock strata of our globe, these indications in what we call meteorites, however slight they may be, are not to be disregarded. While I do not wish to arrogate to myself any undue merit in the study of this subject, I must say that I believe that my methods published in 1855* set forth more prominently than it had been done before, the proper method of research for arriving at correct conclusions. It is clear that to attain positive results, the astronomer, physicist, mineralogist, and chemist must not run counter to one another in the use of the facts severally studied by them; and in all that I have done in this direction, it has been my effort to keep this in view.

In the present memoir, it is my object to develope new facts, and consider some points in connection with the carbon of meteorites.

1. *The Carbonaceous Meteorites.*

Certain well known meteorites, from among those whose fall has been observed, have been called, from their aspect, and from their containing a small amount of carbon, *carbonaceous* meteorites, although the small amount of carbon contained in them is not sufficient to account for their color. Perhaps the term *melanotic* meteorite would be a more appropriate one, to distinguish them from the stony and iron meteorites. There

* This Journal, II, xix, 153, 322.

are but four of them yet known, viz: that which fell at Alais in 1806, that at Kold-Bokeveldt in 1838, that at Kaba in 1857, and that at Orgueil in 1864. They contain, respectively, about 3, 2, 0·6, and 6 per cent of carbonaceous matter.

I would here remark that the Alais, Kold-Bokeveldt, and Orgueil are more closely allied to each other than to the Kaba meteorite. The predominating mineral constituents are about as follows:

	Alais, by Berz.	K-Bokt., by Harris.	Kaba, by Wöhler.	Orgueil, by Pisani.
Silica	31·22	30·80	34·24	26·08
Magnesia	22·21	22·20	22·39	17·00
Iron protoxide	29·03	29·94	26·20	29·60

If we now contrast these mineral constituents with those predominating in well-known meteoric stones, a most striking fact presents itself—one not commonly realized by those engaged in the study of these bodies. It is seen on comparing the above with the following tables:

	Chassigny.	Chateau Renard.	Harrison City.	Concord.	Danville.	Searsmont.
Silica	35·30	38·13	47·30	47·30	50·08	40·61
Magnesia	31·76	17·67	24·53	24·53	20·14	36·34
Iron protoxide	26·70	29·44	28·03	28·03	19·85	19·21

From these tabular statements, it will be seen that, deducting the small amount of carbon contained in the black meteorites, the mass of mineral matter constituting them is about the same, and corresponds thus with the so-called common type of meteoric stones; and hence the mineral matter to which these constituents belong must be the same in the two classes of meteorites, viz: olivines and pyroxenes, differing only in the more or less compact form of these minerals.

In the writings of some of the most astute observers of these bodies, we find little stress laid on these facts. Thus, M. Meunier, in a paper on the origin of meteorites, published in the Cosmos of December, 1869, expresses his amazement that I should speak of the circumscribed uniformity of the composition of meteorites as evidence of a circumscribed cosmical origin of these bodies, both with reference to the sphere or spheres whence they come, as well as their rock structure. He takes so opposite a view as to say (p. 9), "So far from the meteorites showing such a resemblance, we can establish between meteoric iron, olivine meteorites, aluminous meteorites, and carbonaceous meteorites, differences as great as between the most different terrestrial rocks." An assertion which would include all the ranges of rocks and sedimentary deposits from the basalt and granite to the cretaceous and tertiary deposits.

Let any one look at the above table, and say whether or not

he sees so vast a difference in the mineral constituents of the different meteorites there enumerated; and yet they represent the two extremes of these bodies so far as their external properties are concerned. It is well known that three or four minerals represent the great mass of the constituents of every meteorite in various proportions, viz: nickeliferous iron, olivine, pyroxene, and anorthite, especially the first three; and the purely iron meteorites must be recognized as magnified masses of the metallic particles to be found in every stony meteorite, not excepting even the carbonaceous meteorites.*

My object, however, in this paper is not to discuss at length the general internal resemblances of these bodies, as I may have occasion to do it more fully at another time. I wish simply to note, that black and pulverulent as are the carbonaceous meteorites, they are not removed by their mineral constituents from the so-called common meteorites. I now pass on to show that even in their carbonaceous constituent they are strongly linked even to the iron meteorites.

2. *Graphite carbon in the Iron Meteorites.*—Ever since the internal structure of this class of meteorites has been examined by sections through the center of these compact metallic masses, nodular concretions have been noted in their interior, the most common of which consist of *troilite*, a protosulphide of iron, and filling ovoidal cavities. Sometimes these troilite concretions have a thin coating of a lighter colored mineral known as *schreibersite;* and this last is also found alone in concretionary masses which are usually angular or lamellar.

Less frequent concretions than either of the above, and even more remarkable, consist of carbon of the character of graphite: these, like the troilite, usually fill irregular ovoidal cavities, and are more or less contaminated with the latter mineral.

The most important of the meteoric irons containing these nodules, that have come under my immediate observation, are the Toluca, the Cranbourne, the DeKalb, and the Sevier: the last two have received my special study, the latter furnishing much the larger part of the material in my hands.

Character of the graphite nodules.— These concretions differ more or less in appearance, while their general character is the same. In this communication I call special attention to a large nodule taken from the very center of the Sevier iron, the largest that has come under my observation, and perhaps the largest known. It was detached from the iron entire and perfect in every respect. Its greatest length is 60 mm.; its dimensions in

* At present, the Orgueil and Rhoda meteorites are the only two in which no positive evidence of the presence of nickeliferous iron has been traced; in the Orgueil, however, we find nearly three per cent of oxides, nickel and cobalt, and the Rhoda has not been very critically examined.

the other direction vary from 20 to 35 mm. The weight before it was cut was 92 grams. Its form is that of an irregular dumb-bell, flattened on one side, and slightly nodular on the surface. Its color is plumbago-black, except at small places on the surface, where there is a little bronze-colored troilite. Its texture is remarkably close and compact, and it is cut readily by the saw except when the tool encounters particles of enclosed troilite. Its structure and powder is not unlike that of the close-textured graphite of Borrowdale in Cumberland, England, and quite unlike the scaly graphite such as that from Ceylon, or that found in certain cast irons.

Examined from the circumference to the center this nodule presents the following appearances: About one-fifth of the circumference of the section is made up of troilite with a thickness of one millimeter. The remainder of the section has all the aspect of graphite, except in a few spots. In the nodule there is a small mass of troilite not unlike in form the entire nodule; it is 10 mm. long by about 5 mm. wide; it is not continuous from its circumference to its center, but the center portion is cut off completely from the exterior portion by a thin belt of graphite one-half to three-quarters of a millimeter in thickness. Again on other parts of the surface small particles of troilite are to be seen.

The specific gravity of this graphite is 2·26 mm., as determined on a piece in which no troilite was visible to the eye, and after it was immersed in water and placed under the receiver of an air pump to abstract the air from its pores.

Chemical character of the graphitic nodule.—When pulverized and heated in a short glass tube from 100° to 150° C., water is given off which is doubtless water absorbed from the air by the graphite. If heated a little higher and then brought close to the nose, a slight empyreumatic odor is apparent; if heated still higher, there is a slight odor of sulphuretted hydrogen. If heated in the open air the carbon is burnt with difficulty, showing its true graphitic nature.

Treatment of the graphite by ether.—Very pure and concentrated ether was added to two grams of material in powder and rubbed up in a porcelain mortar; then poured into a small beaker; a little more ether was added and the two allowed to remain together for 12 or 18 hours, the vessel being covered to prevent evaporation. The ether was then filtered off from the graphite which was finally washed with a little ether. The ether was allowed to evaporate slowly in the uncovered beaker placed where the temperature was about 33° C. After the ether had evaporated, long colorless acicular crystals covered the sides of the vessel, and some shorter ones were in the bottom. There were also some rhomboidal crystals and rounded particles. The

solid residue exhaled a peculiar odor of an aromatic character, somewhat alliaceous. The quantity of these crystals was small, not exceeding 15 milligrams from two grams of the graphite. Heated on a piece of platinum foil they fuse at about 120° C. Heated in a small tube closed at one end, they first melt and then volatilize, condensing in yellow drops that soon solidify leaving a carbonaceous residue. They are not soluble in alcohol, but very soluble in sulphide of carbon. Fuming nitric acid oxidizes the material, and gives, as one of the products, sulphuric acid. The quantity was too small to admit an ultimate analysis, but it was very evident that sulphur was the predominating constituent, the remainder being carbon and hydrogen. These three elements may be combined, forming a peculiar sulph-hydrocarbon, which in a previous note I called *celestialite*, or it may be sulphur containing a minute quantity of a hydrocarbon that gives the peculiar odor and determines the somewhat singular form of crystallization of the sulphur; for these acicular crystals may be only elongated rhombohedrons.

Be the compound what it may, it is a matter of chemical and astronomical interest that a solid graphite nodule thus encased in iron should contain a sulph-hydrocarbon, or free sulphur and a hydrocarbon.

The graphite powder, after treatment with ether, was then treated with bi-sulphide of carbon (which was re distilled just before use) and after standing two or three hours was thrown on a filter; the filtrate was evaporated to dryness, and the residue was a yellow solid; in this instance, as in the last, the quantity was small. This, when heated in the open air on platinum foil to a red dull heat, first melts at about the temperature that sulphur melts, and finally the sulphur is burnt off, leaving a carbonaceous residue. When heated in a tube, it sublimes, leaving a black residue.

To all appearances this is the same substance, or mixture of substances, that was extracted by the ether, the ether not having exhausted the graphite in the first treatment.

The graphite nodules of the DeKalb and of the Cranbourne irons, on treatment with ether and sulphide of carbon, gave similar results. In the case of the Cranbourne graphite I had less than one hundred milligrams of the material to operate with, and I hardly hoped to obtain satisfactory results, but I did succeed, however, in obtaining such without the acicular crystals, for the whole residue was less than one milligram; but I had enough to recognize the peculiar odor, and also the minute quantity that could be scraped off the vessel in which the evaporation took place furnished the marked reaction by heat of volatilization in part and condensation of the same

with a carbon residue. The Cranborne graphite requires more trituration with the ether than that from the Sevier meteorite as it is more flaky on being rubbed up.

Further remarks about this peculiar substance will be made a little farther on, when I come to speak of the same compound as obtained from the black or carbonaceous meteorites.

[To be continued.]

ART. LI.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXXVIII.—*On the Oxidation product of Glycogen with Bromine, Silver Oxide and Water;* by R. H. CHITTENDEN, Ph.B., Assistant in Physiological Chemistry.

WHILE submitting an aqueous solution of glycogen to the action of bromine in an open vessel with the aid of heat, it was observed that the strong opacity of the fluid gradually disappeared, and that, after the removal of the free bromine by partial evaporation, a perfectly clear fluid remained which contained considerable combined bromine.

This reaction, indicating union between the glycogen and bromine, pointed to the possibility of the formation of an acid from the glycogen by oxidation, in a manner analogous to the formation of "dextronsäure" from dextrin, and "lactonsäure" from lactose, as described by Habermann,* Barth and Hlasiwetz.† The following experiments were undertaken to form, if possible, a corresponding acid from glycogen. The glycogen employed was prepared from the muscular tissue of *Pecten irradians*,‡ and was as pure as could be obtained. The process of oxidation was as follows: fifty grams of glycogen dried at 100° C., were dissolved in 300 c.c. of distilled water, and this solution transferred to a champagne flask fitted with a caoutchouc stopper, in which was a small stout glass tube drawn out to a point.§ Forty grams of bromine were then added and the stopper wired in. The flask was then heated in a water bath until the red vapors of bromine had entirely disappeared, which required about two hours' boiling. A heavy light yellow or white precipitate formed at first, which completely disappeared by the time the bromine had all been taken up. At the end of this first treatment the fluid was perfectly clear and of a pale yellow color. After cooling, the gases were allowed to escape, by breaking the end of the tube in the cork, and, being collected, were found to consist mainly of carbonic acid and bromoform. The stopper was then removed and 40 grams more bromine

* Annalen der Ch. u. Pharm., clxii, 297. † Ibid., cxxii, 96.
‡ This Journal, III, vol. x, p. 26. § Annalen der Ch. u. Pharm., clix, 315.

added. The flask was then closed and heated as before until the bromine had all been taken up, after which, on cooling, the gases were liberated and 40 grams more bromine added, and the flask treated as before. After this, 10 grams of bromine were added three times, so that 150 grams of bromine were employed in the oxidation of 50 grams of dried glycogen.

The fluid was then transferred to an evaporating dish and heated on a water-bath until somewhat concentrated. When cool the fluid was diluted with an equal volume of water, then mixed with freshly precipitated and thoroughly washed silver oxide until all bromine was removed from the fluid. After the silver bromide had completely settled, the fluid was filtered off and the silver contained in it precipitated by hydrogen sulphide. The silver sulphide was removed by filtration, and the filtrate upon partial evaporation left a yellowish-red fluid with strong acid taste and reaction. This was an impure solution of an acid which decomposed carbonates with avidity. In this manner 150 grams of dried glycogen were oxidized, in parts of 50, giving in all sufficient acid for the following experiments. Two methods of purification were employed. The first consisted in treating this impure solution of the acid with chemically pure animal charcoal, and precipitating the filtrate with an excess of alcohol, to remove inorganic salts derived from the glycogen, which the latter always contains in small quantity. This alcoholic filtrate is evaporated on the water-bath, when a moderately pure solution of the acid results.

The second and better method, however, is to treat the impure acid with pure calcium carbonate, on the water-bath, when a soluble calcium salt is obtained which is filtered off, and, after concentration, crystallizes out on standing several days. After washing the crystals with a little cold water, they are dissolved in a large quantity of hot water, and precipitated while still hot by basic lead acetate. This precipitate of a lead salt of the acid is washed with hot water, then emulsionized with water and decomposed by hydrogen sulphide. The lead sulphide is removed by filtration, the fluid evaporated, and then mixed with an excess of dilute alcohol. The precipitate, if any forms, is filtered off, and the filtrate on evaporation leaves the pure acid as a thick colorless syrup, which, after standing several months, shows as yet no signs of crystallization. A solution of the acid in water has an acid reaction on litmus; a strong acid taste; is not precipitated by alcohol, and dissolves freshly precipitated hydrated copper oxide to an azure-blue fluid, which remains blue when heated, but after long boiling shows strong reducing action.

Calcium Salt.—On treating an aqueous solution of the acid with calcium carbonate, on the water-bath, a violent evolution of carbonic acid takes place, and, after some time, a soluble calcium

salt can be filtered off from the excess of calcium carbonate. If the solution is at all colored it can be purified by animal charcoal. When suitably concentrated, this solution on standing several days, changes into a mass of irregular white globules, which are aggregations of fine microscopic needles.

The air-dried salt, when heated to 100° C. loses only hygroscopic water, and, when heated above 100° C. turns brown, which would indicate decomposition. The salt after crystallization is difficultly soluble in cold water; readily soluble in hot water, and is precipitated from its aqueous solution by alcohol.

The analysis of the salt gave the formula: $C_6H_{11}Ca'O_7$.

I. 0·2097 grams of the salt dried at 100° C. gave ·2552 grams CO_2 and ·1015 grams H_2O.
II. 0·317 grams of the dried salt gave ·3851 grams CO_2 and ·1508 grams H_2O.
III. 0·3305 grams of the dried salt gave ·0429 grams CaO.
IV. 0·272 grams of the dried salt gave ·036 grams CaO.

	Calculated.	Found.			
		1.	2.	3.	4.
C_6	33·49	33·18	33·12	----	----
H_{11}	5·12	5·37	5·28	----	----
Ca'*	9·35	----	----	9·27	9·45
O_7	52·05	----	----	----	----

Barium Salt.—On treating a portion of the acid on the water-bath with barium carbonate, the latter salt is decomposed, and a soluble barium salt of the acid results. The salt thus formed does not crystallize readily from this solution. Alcohol is then added in excess to the fluid, when a heavy white precipitate forms, flocculent at first, but soon becoming gummy. This precipitate is washed with alcohol, and after drying has the appearance of a hard yellow gum. The gum-like mass is dissolved in water, filtered through animal charcoal, and evaporated to a small bulk, when, after standing a week, the fluid is converted into a mass of quite large, white, glassy prisms, which contain water of crystallization.

The analysis of the salt dried at 100° C. gave the formula: $C_6H_{11}Ba'O_7$. The air-dried salt gave the formula: $C_6H_{11}Ba'O_7+1\frac{1}{2}H_2O$.

I. 0·347 grams of the salt dried at 100° C. gave ·3488 grams CO_2 and ·1402 grams H_2O.
II. 0·2778 grams of the dried salt gave ·2793 grams CO_2 and ·1102 grams H_2O.
III. 0·498 grams of the dried salt gave ·1872 grams $BaCO_3$.
IV. 0·3117 grams of dried salt gave ·1175 grams $BaCO_3$.
V. 1·2257 grams of the air-dried salt gave by drying at 100° C. ·11542 grams H_2O.

* Ca′=20.

	Calculated.	Found.				
		1.	2.	3.	4.	5.
C_6	27·32	27·41	27·41	----	----	----
H_{11}	4·17	4·48	4·40	----	----	----
Ba′*	25·99	----	----	26·14	26·21	----
O_7	42·54	----	----	----	----	----
$1\frac{1}{2}H_2O$	9·64	----	----	----	----	9·41

The crystals of this salt are very readily soluble in hot and cold water, but insoluble in alcohol.

The air-dried crystals when placed over concentrated sulphuric acid lose 6·42 per cent of water. The calculated amount for one molecule of water is 6·74 per cent. On drying the crystals at 100° C. the remaining one-half molecule is driven off. Heated at 120° C. the crystals turn brown and swell up.

Cadmium Salt.—On treating an aqueous solution of the acid with cadmium carbonate, on the water-bath, a soluble cadmium salt is obtained which does not crystallize. The salt is precipitated from its solution by three or four volumes of alcohol, then redissolved in water, filtered through animal charcoal, and reprecipitated by alcohol. It is thrown down from its solution as a flocculent precipitate which soon becomes gummy, and when hard yields on trituration a perfectly white powder.

The analysis of the salt dried at 100° C. gave the formula: $C_6H_{11}Cd'O_7$.

I. 0·3924 grams of the salt dried at 100° C. gave ·4105 grams CO_2 and ·1618 grams H_2O.

II. 0·3544 grams of the dried salt gave ·3702 grams CO_2 and ·1412 grams H_2O.

III. 0·344 grams of the dried salt gave ·0989 grams CdS.

IV. 0·3568 grams of the dried salt gave ·1023 grams CdS.

	Calculated.	Found.			
		1.	2.	3.	4.
C_6	28·68	28·52	28·48	----	----
H_{11}	4·38	4·58	4·42	----	----
Cd′†	22·31	----	----	22·36	22·29
O_7	44·70	----	----	----	----

Cobalt Salt.—On heating an aqueous solution of the acid with cobaltic carbonate, on the water-bath, a cherry-red solution of a cobalt salt of the acid, is obtained, which does not crystallize readily from the aqueous solution. On the addition of alcohol to a concentrated or only moderately dilute solution of this salt, a heavy pink colored precipitate forms which soon becomes gummy.

This precipitate, after being washed with alcohol and dried at 100° C. gave by analysis the formula: $C_6H_{11}Co'O_7$.

* Ba′=68·5. † Cd′=56.

I. 0·279 grams of the salt dried at 100° C. gave ·325 grams CO_2 and ·1213 grams H_2O.

II. 0·283 grams of the dried salt gave ·3325 grams Co_2 and ·1200 grams H_2O.

III. 0·2005 grams of the dried salt gave ·0268 grams Co.

	Calculated.	Found.		
		1.	2.	3.
C_6	32·07	31·76	32·04	----
H_{11}	4·89	4·83	4·71	----
Co'*	13·14	----	----	13·36
O_7	49·89	----	----	----

From a very dilute solution in water, the cobalt salt is precipitated by alcohol in the form of pink flocks. On allowing this precipitate to stand several weeks in the alcoholic fluid, it will be found to have changed its form, and under the microscope, will be seen to consist of fine needle-shaped crystals. These crystals dried at 100° C. gave by analysis the formula: $C_6H_{11}CoO_7+H_2O$.

I. 0·219 grams of the salt dried at 100° C. gave ·2372 grams CO_2 and ·108 grams H_2O.

II. 0·2992 grams of the dried salt gave ·3225 grams CO_2 and ·1484 grams H_2O.

III. 0·2052 grams of the dried salt gave ·0254 grams Co.

	Calculated.	Found.		
		1.	2.	3.
C_6	29·69	29·53	29·40	----
H_{13}	5·36	5·47	5·51	----
Co'*	12·16	----	----	12·37
O_8	52·78	----	----	---

Manganese Salt.—A solution of the acid treated, as in the preceding methods, with manganic carbonate, forms a soluble manganese salt which separates from the suitably concentrated fluid in masses of fine microscopic feather-like crystals. These crystals upon close examination are seen to be made up of radiating needles. When agitated in water they have a brilliant silky luster. They are slightly yellow, soluble in water, but insoluble in alcohol. The salt dried at 100° C. gave by analysis the formula: $C_6H_{11}MnO_7$.

I. 0·305 grams of the salt dried at 100° C. gave ·362 grams Co_2 and ·142 grams H_2O.

II. 0·353 grams of the dried salt gave ·062 grams Mn_3O_4.

	Calculated.	Found.	
		1.	2.
C_6	32·35	32·36	----
H_{11}	4·94	5·17	----
Mn'†	12·35	----	12·65
O_7	50·33	----	----

* $Co'=29·5$. † $Mn'=27·5$.

Lead Salt.—On treating an aqueous solution of the calcium salt with basic lead acetate, best with the application of heat, a heavy white gelatinous precipitate is obtained, which after washing with hot water and drying at 100° C., yielded by analysis the formula: $C_6H_8Pb_2O_7$.

I. 0·280 grams of the salt dried at 100° C. gave ·115 grams CO_2 and ·0358 grams H_2O.

II. 0·3855 grams of the dried salt gave ·1645 grams CO_2 and ·0505 grams H_2O.

III. 0·436 grams of the dried salt gave ·3212 grams PbO.

IV. 0·1522 grams of the dried salt gave ·1122 grams PbO.

	Calculated.	Found.			
		1.	2.	3.	4.
C_6	11·88	11·20	11·63	----	----
H_8	1·32	1·42	1·45	----	----
Pb''_2	68·31	----	----	68·38	68·43
O_7	18·49	----	----	----	----

On adding a solution of neutral lead acetate to an aqueous solution of the acid, a white flocculent precipitate is obtained. A similar precipitate is obtained with basic lead acetate. These precipitates, after washing with water and drying at 100° C., gave by analysis the following results:

	Precipitate produced by neutral lead acetate.		Precipitate produced by basic lead acetate.
C	11·60	C	11·42
H	1·42	H	1·55
Pb	68·19	Pb	68·66
O	18·79	O	18·37

A silver salt was also obtained as a flocculent precipitate. This was not analyzed.

By a backward glance we see that in all the salts obtained, with the exception of the lead salt, the acid acts as a monobasic acid. In the case of the lead salt, however, four atoms of hydrogen are replaced by two atoms of the metal. Hlasiwetz in an article upon the basicity of "lactonsäure" and "gluconsäure,"* in which he shows that these acids are not only monobasic but also dibasic, gives a method whereby he obtained a dibasic barium salt from a monobasic calcium salt. On treating an aqueous solution of the monobasic calcium salt of this acid in the same manner, viz: with baryta water, and heating to boiling, a white flocculent precipitate is obtained, which after washing with hot water and drying at 100° C. gave by analysis the formula: $C_6H_{10}Ba''O_7$.

I. 0·282 grams of the salt dried at 100° C. gave ·2192 grams CO_2 and ·0905 grams H_2O.

II. 0·1585 grams of the dried salt gave ·1235 grams CO_2 and ·0505 grams H_2O.

III. 0·3255 grams of the dried salt gave ·192 grams $BaCO_3$.

* Annalen der Ch. u. Pharm., clviii, 253.

	Calculated.	Found.		
		1.	2.	3.
C_6	21·75	21·19	21·24	----
H_{19}	3·02	3·56	3·54	----
Ba	41·38	----	----	41·01
O_7	33·83	----	----	----

The formation of this salt, together with the lead salt, shows that from this acid both monobasic and dibasic salts can be formed.

The formula of the acid is $C_6H_{12}O_7$ and in the oxidation of the glycogen we can assume that the following reactions take place: $C_6H_{10}O_5+H_2O+2Br=C_6H_{12}O_6Br_2$. Adding silver oxide to the bromine compound we have:

$$C_6H_{12}O_6Br_2+Ag_2O=C_6H_{12}O_7+2AgBr.$$

From analogy, it would seem proper to apply to this acid the name glycogen acid.

The preceding analyses and reactions show conclusively that by the action of bromine, water and silver oxide on glycogen, an acid is formed which bears the same relation to glycogen as "dextronsäure" to dextrin. On comparing this acid with the descriptions of "gluconsäure"* and "dextronsäure,"† we see that the glycogen acid differs from the two no more than the two differ from each other. There is also the same relationship existing between glycogen acid and the acid or acids obtained by the oxidation of amylum and paramylum‡ by Haberman, which latter show but few points of difference from "gluconsäure" and "dextronsäure."

February 26th, 1876.

ART. LII.—*On the existence or not of Horns in the Dinocerata;* by RICHARD OWEN. (Letter to the Editors of this Journal, dated London, Feb. 24, 1876.)

GENTLEMEN: Among the new forms of extinct Eocene mammals of America, for which science is indebted to Professor O. C. Marsh, those which he refers to "the new order *Dinocerata*" are the most singular.

The study of their characters, especially as described and illustrated in your Journal,§ has led me to submit a few remarks on the subject of "horns." These weapons in mammals, if formed or supported by bone, are either "autogenous" or "exogenous," either "epiphyses" or "apophyses;" terms which signify, in a word, either, that the horn is ossified from an independent center and

* Annalen der Ch. u. Pharm., clv, 120. † Ibid., clxii, 297. ‡ Ibid., clxxii, 11.
§ Vol. xi, February, 1876, p. 163.

afterwards coalesces with a cranial bone, or that it grows, as a process, from a cranial bone.

The giraffe yields an instance of the "autogenous" horn, and its skull, in either the recent or fossil state, shows the basal sutures. In other species the horns or horn-cores are "exogenous;" and such, in the absence of the sutural evidence, are the parts called "horn-cores" in the *Dinocerata.*

But before elevations or processes of cranial bones can be pronounced to be "horn-cores," the evidence of the horns they supported should be forthcoming. Paleontology, it is true, infers the existence of horns supported on bony bases, or "horn-cores," in extinct species in which such horns have perished. *Bos antiquus*, *Bison priscus*, *Sivatherium*, *Bramatherium*, are rightly referred to the "hollow-horned" group, and the two latter may seem more germain to the present question, seeing that the "horn-cores" are in two pairs. Such conclusion is based on the presence of foramina and ramified grooves upon the surface of the "cores," which are known to be the effects of the penetration and pressure of blood-vessels supplying the growth and renovation of the horny sheaths of such bony processes. The same evidence reveals the true nature of the horn-cores, which may be covered with skin instead of horn, such as are the horns of deer, from which when complete the skin is shed.

In the absence of such evidence the paleontologist infers that smooth unfurrowed protuberances or processes of cranial bones were covered, like the rest of the outer surface of the bones developing them, with persistent periosteum and skin, in the existing animal. He refrains from calling them "horn-cores," and from defining the extinct species manifesting them, as "horned," "four-horned," or "six-horned," *Dicerata*, *Tetracerata*, *Hexacerata;* or, as in the case of the hornless herbivores of the Wyoming Eocene, *Dinocerata:* because such terms imply the possession by those extinct quadrupeds of weapons of which there has not, at present, been given any evidence.

Professor Marsh, indeed, candidly admits in regard to the protuberances which suggested the generic name *Dinoceras*, that they "may possibly have been covered with thick skin and not with true horn."† But we have no evidence of the integument having been thicker, or other on the protuberances than on the cranial bones developing them.

It may be noted that the hornless exceptions in the group of existing herbivorous quadrupeds with true horn-cores and horns, the hornless *Moschidæ*, e. g., are furnished with other weapons of defense, a pair, namely, of long, edged, and sharp-pointed canines descending from the upper jaw.

The hornless *Dinoceras* was similarly armed, and Professor Marsh believes he has evidence of a sexual difference of size in those dental weapons, which would yield another analogy to the existing Musk-deer. But the dental and osteal characters of the

† Loc. cit., p. 164.

pentadactyle *Dinoceras* are consistently "perissodactyle." The truly remarkable peculiarity of its skull is the tendency of the outer wall of the bones to extend into ridges and bosses; and this not only in the cranium proper and upper jaw, but also in the lower jaw. If these bosses were legitimately interpretable as "horn-cores," we must give the animal a pair of horns descending from the under and forepart of the mandible to match the pair ascending from the maxilla. But the singular processes descending and diverging, as a pair, from the mandibular rami, show as marked an absence of any indication of their having been sheathed with horn as do the pairs of protuberances from the nasal, maxillary, and the frontal bones above.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Diplometer.*--M. Landolf has invented an instrument for measuring the diameter of objects without touching them and independently of their movements. A wedge-shaped piece of glass is cut in two along a plane perpendicular to the edge of the wedge, and joined together again after turning one piece 180°. Looking through the line of junction of the prisms, objects will appear double, because the prisms will deviate the rays in opposite directions. When the two images appear just in contact the doubling will be just equal to the diameter of the object. Hence knowing the distance we can compute the diameter, or *vice versa.* The prisms slide over a graduated rod so that the object being placed at one end they are moved until the two images are just in contact, when the distance furnishes a ready means of determining the diameter. In the instrument actually constructed a distance of 42 mms. corresponded to an overlapping of 1 mm. Consequently tenths of a millimeter were readily measured. Evidently motions of the object do not affect the measure since both images move together.—*Comptes Rendus*, lxxxii, 424.

[Numerous applications of this instrument will suggest themselves. In natural history the dimensions of various parts of animals or plants, whether large or small may be found, and in physics objects which cannot be touched, as bubbles, vibrating bodies, &c., may be quickly measured. By setting the prisms as an eye-glass this instrument would form a convenient substitute for a telescope, in measuring distances with a telemeter.] E. C. P.

2. *Specific Heat of Gases.*—M. Wiedemann has published in full his measurements of the specific heat of gases referred to in a recent number of this Journal (cviii, 465). His results are given in the following table in which the first column gives the name of the gas, and the second, third and fourth its specific heat under constant pressure at temperatures of 0°, 100° and 200°. The last

three columns give the corresponding specific heats under constant volume:

Name.	Constant Pressure.			Constant Volume.		
	0°	100°	200°	0°	100°	200°
Air,	·2389			·2389		
Hydrogen,	3·410			·2359		
Carbonic oxide,	·2426			·2346		
Carbonic acid,	·1952	·2169	·2387	·2985	·3316	·3650
Ethyl,	·3364	·4189	·5015	·3254	·4052	·4851
Nitrous oxide,	·1983	·2212	·2442	·3014	·3362	·3712
Ammonia,	·5009	·5317	·5629	·2952	·3134	·3318

—*Pogg. Ann.*, clvii, 1. E. C. P.

3. *Crooke's Radiometer.*—Mr. G. J. STONEY presents an explanation of the apparent repulsion produced by heat, according to the Kinetic theory of gases. Mr. Crookes has shown that the pressure produced on a blackened surface of two square inches by the light of a standard candle six inches distant would be ·001772 grains or somewhat less than ·01 milligram per square centimeter. Assuming that the pressure of the air in the interior is reduced to ·1 mm. there would still be something like a hundred million of millions of atoms in each cubic millimeter. These atoms will consist in part of oxygen and nitrogen from the air, of mercury and hydrocarbons, and probably in part of platinum, glass and other substances in a gaseous form.

The blackened surface will be heated by the candle more than the glass by an amount which may be assumed at ·1° and the air in contact with it will vary in temperature from that of the disk to that of the enclosing air. Were the air at its ordinary pressure the heated layer would be very thin, and may be estimated at about ·0005 mm., or about the wave-length of green light. With the small pressure here employed, however, the case is quite different, and the thickness of the layer would equal $\cdot0005 \times (7600)^{1\cdot33}$, or over a decimeter. The heated layer therefore extends to the wall of the surrounding vessel, and now a heat engine is formed by the particles of air which strike the disk with a velocity due to a temperature of perhaps 15°, and are repelled from it with a velocity due to its temperature of 15·1°. The resultant pressure on the disk may be readily computed and is found to be ·0115 milligram which agrees closely with ·01, as observed by Mr. Crookes. In other words a difference of temperature of ·1° C. is sufficient to account for the observed pressure.—*Phil. Mag.*, l, 177.

[The measurement here referred to, is described in *Engineering*, Feb. 18th, and was effected in the following manner: A torsion balance was constructed with a horizontal glass fiber and with a horizontal arm terminating in a cup at one end and in a disk of pith at the other. A small piece of iron weighing a hundredth of a grain was raised by a magnet and dropped into the cup. It was then found that the fiber must be turned through 100021° to bring the arm back to its original position. The light of a candle at a distance of 6 inches was next allowed to fall on the pith, when a torsion of 1775° was required to bring it back. This corres-

ponds to ·001772 grains, or about an eighth of a grain per square foot. From this it would appear that the light of the sun would be equivalent to 32 grains per square foot or 57 tons per square mile. Mr. Crookes further applies this instrument as a photometer and suggests its application to observatories to determine the total amount of sunlight received during the year. The number of revolutions could be counted by attaching a magnet to the radiometer which should act on a magnetic needle moving a counter outside of the glass case. Similarly the power of the instrument might be transmitted through the glass without the usual loss by friction.

Numerous other articles appear on the same subject. Poggendorff and Neesen (Bibl. Univ., ccxvii, 84, and Phil. Mag., l, 251) publish independent series of experiments from which they conclude that the repulsion is due to convection currents. Several articles appear also in 'Nature,' on the radiometer; on p. 391, Mr. Crookes shows that the repulsion is inversely as the square of the distance and compares the effect of rays of various wave lengths. On page 324, Mr. Hutchinson states that a radiometer with mica vanes on metallic supports revolves more rapidly with dark heat than with light, but Mr. Crookes replies that pith should be used as the absorbing substance, since metals give erratic results.] E. C. P.

4. *The Gram Magneto-electric machine.*—M. Tresca has made a careful measurement of the power required to drive a large and a small gram machine and compared the result with the light generated. A photometer disk was used, of which one portion was illuminated only by the electric light and an adjacent portion only by a carcel burner consuming 40 grams of oil per hour. Much trouble was experienced from the difference in color of the two lights, and the equality was best obtained by interposing two plates of glass, one of light green and the other of light pink. Owing to irregularities in the carbons the light continually underwent irregularities sensible only to the photometer. The light of the larger machine was placed 40 meters from the disk and the burner moved until the square of their distance should be as 1850:1, which was about the mean ratio of the two lights. When the two portions of the disk appeared equally bright the observer gave a signal and instantly the power and velocity were observed. The larger machine had a length of 80 cms., width 55 cms., and height 58·5 cms. The average number of turns per minute was 1274, and the work 576 killogrammeters or 7·68 horse-power. The light being 1850 burners, would equal ·415 of a horse-power per 100 burners, or ·31 kgms. per burner.

The smaller machine had a length of 65 cms., breadth of 41 cms., and height of 50·6 cms. It made 872 turns per minute, and gave a light of 302·4 burners. This required 211 kgms., or 2·8 horse power, equivalent to ·92 of a horse power per hundred burners, or ·69 kgms. per burner.

The consumption of oil to produce a light equal to that of the larger machine would be about 71 kgs. per hour or 194 cubic

meters of gas. The cost of the oil would be therefore in Paris about a hundred times that of the electric light, or that of gas fifty times, to produce the same light. The comparison with the smaller machine would be less favorable. The carbons for the larger light had a cross section of 81 mms., and the ordinary consumption was a little over a centimeter in length per hour.—*Comptes Rendus*, lxxxii, 299. E. C. P.

5. *Effect of increase of temperature on the Index of Refraction;* by Professor T. P. MENDENHALL. Letter to the editors, dated Columbus, Ohio, April 10, 1876.—Dear Sirs: I have in progress an investigation of the effect of increase of temperature on the index of refraction, which has at this time yielded some results of considerable importance to spectroscopists. In 1858 Messrs. Gladstone and Dale announced as the conclusion of a research upon this question, that in every substance the refractive index diminishes as the temperature increases. I am satisfied that glass at least does not obey this law; that, on the contrary, with it the index increases with the temperature. In my experiments I have used equilateral glass prisms with indices of refraction of about 1·63. The change in the position of the D line has been observed with a parallel wire micrometer. That the effect was not due to a change in the angle of the prism during the process of cooling I satisfied myself—both by measurement of the angle when hot and when cold—and by receiving the image of the slit of the collimator reflected from both faces upon the cross hairs of two telescopes properly adjusted upon the instrument. No appreciable change in angle could be discovered. Numerous experiments agree well in fixing the "index of sensitiveness," but the quantitative results I have not fully worked out. I only wish at present to direct attention to the fact, that, in the use of a train of several glass prisms in a spectroscope, ordinary changes of temperature to which the instrument may be subjected will produce a very noticeable change in the position of the spectrum lines. In my own, of five large prisms, of an angle of 64°, the change in the position of the D line on removing the prisms from an open window, the temperature outside being about 32° F., to the room, at ordinary temperature was as much as 95 divisions of the micrometer screw head. With a smaller number of prisms the change was closely proportioned to that number. I wish to suggest that in this way may be found the cause of many discrepancies which occur in tables of wave-lengths, as furnished by different workers, in such cases as those in which the dispersion spectrum has been made use of, and the wave-length computed by interpolation. A great many such cases occur in Watt's Index of spectra. In an instrument of many prisms the observation of temperature will be a matter of vital importance in fixing the exact position of a line. I propose to pursue the investigation, especially in respect to the observation of lines more or less refrangible than the D, and also as to the effect of change of temperature upon other than glass prisms.

II. Geology and Mineralogy.

1. *Does the actual vegetation of the Globe furnish any general marks by which it could be recognized in all countries if it became fossil?*—This question is asked by Alph. DeCandolle in a brief article in the Archives des Sciences of Geneva for December, 1875. The question is answered in the negative, as was inevitable. For, as the author observes, the species of plants over the globe differ so widely with difference of locality that it would be exceedingly difficult, or rather, impossible, to draw the line between differences in species due to local distributions, and those due to successional relations. The difficulties, moreover, are greatly increased through the fact, well illustrated by Dr. Gray, that the vegetation of the northern hemisphere has widely changed place during even the Quaternary, and also more than once in earlier time. It hence follows, as DeCandolle urges, that any conclusions as to the succession or cotemporaneity of species in Europe could not be expected to be applicable to America or the other continents; and even the deposits of the several natural regions of a continent would not admit of being synchronized without great doubts over the conclusions. This special inference is not new to geologists; for they admit that with the best of evidence they cannot make out, except very uncertainly, the equivalency of the successive rocks of Europe and America.

But while this general proposition is well sustained, other questions are suggested by the author which appear to demand a reference to a wider range of facts than his paper considers.

Professor DeCandolle seems to regard all fossils as equally poor registers of geological age with plants. It is certain that fossil plants are a most unsatisfactory means of determining equivalency. *Marine* plants—in wonderful contrast with marine animals—have varied little through the geological ages; and hence if plants are used at all for chronological purposes we are confined, with hardly an exception, to the *terrestrial* species. But the terrestrial species, while much more diverse than the marine, include only a very limited series of distinct types, and floras have continued the same or similar through very long ages. Besides, *terrestrial* species, whether vegetable or animal, are more confined in their distribution through physical conditions than those of salt-water; and, further, they are far more poorly represented in the rocks than marine species. For these reasons, and because of the great doubts that come from migrations, the geologist makes little use of fossil plants except for the purpose of characterizing in a general way the floras of the grander divisions of geological time. In actual fact, geologists, in their subdivisions or identifications of formations, have relied almost solely on evidence from fossil animals, and especially marine animals; and if fossil plants are mentioned as the characteristics of a period or age, it has been, with rare exceptions, only after the question of the period or age has been decided by means

of other evidence. Evidence from these other sources has its doubts, but it is not of so small value as that from plants. This comparative want of value is well illustrated by the present wide divergence between Paleophytologists and general Paleontologists with regard to the age of the plant-bearing beds of the Rocky Mountains, the Arctic regions, and Europe. An allusion to the uncertainties of Botanical evidence in the Rocky Mountain region may be found on page 149 of this volume.

But Prof. DeCandolle makes the evidence from plants of less value, we think, than is reasonable. He says: No one would dare to assert that during the progress of a given bed of Pennsylvania coal, there did not exist somewhere, perhaps far away, an elevated region less moist, on which Angiosperms were already in existence. The supposition is a forced one. For, in Cretaceous and Tertiary times, Angiosperms were the plants of *moist* lands, their leaves abounding in the coal-formations of those eras; and it is hence natural that they should have abounded in moist places also in the Carboniferous age, if in existence then along with the Acrogens and Gymnosperms.

In the Carboniferous period of North America, the peat-making marshes at times spread from Eastern Pennsylvania to Western Iowa and Arkansas, covering an area of more than 500,000 square miles; and, at the same time, there were dry hills or mountains along the borders of the marshes, in New York, New Jersey, Ohio, Wisconsin, Missouri, Arkansas, through all that long age. The Adirondacks were certainly in existence, and the Green Mountains, and the Highlands of New Jersey, and other ridges or mountains beyond the Mississippi. The area of those Carboniferous marshes with their surroundings was large enough, and varied enough in surface, to have borne a fair representation of the flora of that era of approximately uniform climate; and still the streams from the hills conveyed, so far as yet discovered, no leaves of Angiosperms to the marshes that bordered the hills. The Coal-measures of the Arctic bear similar testimony, whether there by migration or not, and so do those of Europe. Further, Permian, Triassic and Jurassic beds overlie the Coal formation both in America and Europe and have afforded no remains of Angiosperms. It is from facts like these that geologists have been led to infer that the flora of those lands during the Carboniferous age had characteristics distinguishing it very decidedly from that of other ages; and to deem it probable that the precursors of the Angiosperms existed then in a state unlike that of a Cretaceous or modern Angiosperm.

Prof. DeCandolle adds, in the same paragraph, that if fossil Angiospermous plants were found by geologists in any rock "that rock would be at once pronounced of the Cretaceous age," [or of later time]. In reply I only repeat that geologists are very generally convinced that the evidence from fossil plants is not to be trusted, and make the plants of whatever age the fossil *animals* present may indicate. The "Cretaceous" plants of the United States are

the plants of beds which had previously been determined, through the animal fossils, to be Cretaceous; and, if geologists finally conclude that the flora of the Lignitic beds is all Cretaceous, it will be done on the ground of the animal relics, and in spite of what has been regarded as good botanical evidence.

While then there may be doubts over chronological conclusions from fossils of whatever kind, the geologist who surveys the whole field finds those doubts less weighty than they would naturally appear to one who looked at the subject from the botanical side alone. J. D. D.

2. *Report of the Geological Survey of Ohio.* Volume II. *Geology and Palæontology.*—Part. II, *Palæontology*, (or, as stated on the cover, Palæontology, Vol. II.) 436 pp. roy. 8vo, with over sixty plates. Columbus, Ohio, 1875.—This large volume contains, after a preface, by Dr. J. S. Newberry, the head of the survey, descriptions of Fossil Fishes, by Dr. Newberry, pp. 1–64; of Silurian Fossils, and of Crinoids from the Waverly group, by J. Hall and R. P. Whitfield, pp. 65–179; of Silurian and Devonian Corals, by H. A. Nicholson, pp. 181–268; of Invertebrate Carboniferous Fossils, by F. B. Meek, pp. 269–347; of Carboniferous Amphibians, by E. D. Cope, pp. 349–411; of Lower Carboniferous fossil plants, by E. B. Andrews, pp. 413–426. The paleontological work was thus in able hands, and covers a large number of species in each of its departments. The portions giving the most novel results are those of the Fishes and Amphibians, and the Lower Carboniferous plants.

Dr. Newberry describes the genus *Dinichthys* from new and magnificent specimens—including broad plates of the venter and back, fifteen inches to two feet in length, a mandible twenty-two inches long, a cranium almost complete, and other bones—and shows that it was closely related to *Coccosteus*. The large ventral pieces were five in number. The anterior end of the mandible was turned up so as to form a strong acute prominent tooth, which had a produced dentate margin in one species. The dentition resembles that of the living *Lepidosiren*; and Dr. Newberry refers the genus (along with *Coccosteus*, *Heterostius*, *Asterolepis*, *Pterichthys*, etc.), to the Lepidosiren group, or the Dipnoa, and agrees with Dr. Günther in placing the Dipnoans and Placoderms with the Ganoids. A species of Coccosteus, *C. occidentalis* Newb., is described from Ohio. Dr. Newberry describes "Conodonts" from the Waverly group, which he is inclined to refer to the Marsipobranchs. He also gives new species of *Cladodus*, *Polyrhizodus*, *Orodus*, *Ctenacanthus*, *Lystracanthus*, *Platyodus*, *Rhynchodus*, *Ctenodus*, *Dipterus*, and introduces the new genus of Ganoids, *Heliodus*, for species near those of *Dipterus*. Dr. Newberry, after remarking that the occurrence together of the spines *Ctenacanthus furcicarinatus*, the teeth *Orodus variabilis*, and certain dermal tubercles, show that they belong to the same species, remarks that impressions of the heterocercal tail, with the fins of the same species, have been observed—one of them six

feet long; and that the lower lobe of the tail consists of rays that were distinctly ossified.

The Batrachians or Amphibians from the Carboniferous beds, and described by Prof. Cope, are referred by him to the order which he has named *Stegocephali;* an order including the *Labyrinthodonts* Owen, and also Owen's *Ganocephala*, and other species recently described which have been called *Microsaurs.* The species are partly lizard-like, with ribs and limbs (as in *Dendrerpeton*, *Hylonomus*, *Amphibamus*, *Colosteus*, *Archegosaurus*, etc.; and part very long and slender, snake-like, with limbs wanting, as in *Molgophis* Cope, which has ribs and probably no limbs, and *Phlegethontia* Cope, which is without both, and includes "true batrachian snakes,"—one imperfect specimen having 56 vertebræ. Prof. Cope also describes a few Amphibians which he refers to the *Proteida.*

The interesting Subcarboniferous plants brought to light and described by Professor E. B. Andrews, have been already noticed in the last volume of this Journal (p. 462) by the author. The turning out of so many new species of unusual forms in a region that had already been long explored is a fact of much geological interest.

The very numerous plates of this volume are well executed.

Dr. Newberry announces in his Preface that Volume III of the Paleontology will contain a general review of the fossil plants of Ohio, with descriptions of new species; a memoir by Prof. O. C. Marsh, on the *Dicotyles compressus*, and on the *Castoroides Ohioensis;* and notices of other Quarternary vertebrate remains, together with some invertebrate fossils yet undescribed. When completed, the series of Ohio reports will rank among the best State-survey publications that have appeared.

3. *Geological Survey of Alabama. Report of Progress for* 1875; by EUGENE A. SMITH, Ph.D., State Geologist. 8vo, 220 pp.—In this volume, a general outline of the Paleozoic formations of Alabama, with brief descriptions of the various beds, by Prof. Smith, is followed by a summary of the facts heretofore known concerning the Coal-fields of the State, prepared by Mr. T. H. Aldrich. The first systematic attempt at mining and shipping coal, in Alabama, is said to have been made in 1853, near the southwestern extremity of the Cahaba coal-field. Mr. Aldrich's paper includes a reprint of parts of an elaborate essay by R. P. Rothwell, published, two years since, in the Engineering and Mining Journal. The coal-series is said to contain ten or twelve veins [seams] of remarkable thickness, i. e., from two feet (average thickness of clean coal) upward, besides a number of smaller beds, several of which are from fifteen to eighteen inches in thickness. These ten or twelve workable beds are distributed in two series or groups, as we find in all our coal-fields, notably in West Virginia, Ohio and Pennsylvania. * * The *maximum available* thickness of coal as yet proved in any portion of the field will not exceed thirty or thirty-five feet; while, if we take the area of the

Cahaba field at 230 square miles, the *average* thickness of workable coal over the entire field would probably scarcely attain fifteen feet. This estimate, so much lower than we have been accustomed to see stated in reports and newspaper articles, is probably not very different from the thickness which the same method of estimating would give for any of our other bituminous coal fields. "The enormous thickness of the coal-bearing rocks in the Cahaba field, being estimated at over 5,000 feet, has no parallel in the Warrior coal-field." Record of four borings in the Warrior field show sections of from 400 to 600 feet of strata, including four, seven and eleven coal-horizons.

Prof. Lesquereux furnishes a list of 57 species of coal-plants, (of which 12 are named as new,) and remarks upon the very low position in the Coal-measure series to which they must theoretically be assigned, a few species, such as *Sternbergia*, *Lepidodendron Weltheimianum* and *Asterophyllites gracilis*, ranging down even into the Devonian. This corresponds with the suggestions already made, by several geologists, that the coal-measures of the Southern States are all very low in the series, the whole having been called "sub-conglomerate" by some writers. We should prefer, however, some more certain evidence on this point than has yet been produced. The surveys of Alabama, Georgia and Kentucky, now in progress, will leave but a short gap (in northern Tennessee) between the well-known fields of Pennsylvania and Ohio and the southern extremity of the system.

The body of the report is occupied with details of County-work, mostly in the Silurian areas of the State. Some analyses of ores are given, besides lists of elevations. There is also a valuable paper by A. R. Grote, on the cotton-worm (*Aletia argillacea* Hübner) which is preliminary, the author states, to a more extended history of the worm. Mr. Grote writes from observations in Alabama on the habits of the worm, and also from a study of it elsewhere. He is an excellent entomologist, and if his reviews are continued in the survey, will add greatly, by his study of the insects injurious and beneficial, to the value of the State Reports.

We understand that the State appropriation, for the work thus reported on, is only $500 a year to cover the *travelling expenses* of the geologist during the vacations of the State University, in which institution he is a Professor. The volume may therefore properly be accounted a personal contribution to the cause of science.

4. *The Geological Record for* 1874.—An account of works on Geology, Mineralogy and Palæontology, published during the year. Edited by William Whitaker, B.A., F.G.S., of the Geological Survey of England. 398 pp. 8vo. London, 1875. (Taylor & Francis.)—Mr. Whitaker, the editor of the Geological Record, has had able co-workers, and has produced a volume which will be found of great value to all of all lands that are interested in the progress of geological science. The sub-editors are the following, all members of the Geological Society: W. Topley, G. A.

Lebour, F. Drew, and R. Etheridge, Jr., for Descriptive Geology; Professor A. H. Green, for Physical Geology; F. W. Rudler, for Mineralogy and Petrology; and L. C. Miall, Prof. H. A. Nicholson, and W. Carruthers, for Paleontology. The number of works and memoirs mentioned by title is very large, and, for much the larger part, short abstracts are given, which appear to have been carefully prepared. American publications are included, as well as those of other continents, and are judiciously treated. Some omissions we note, of papers in the Publications of Societies. This volume is to be the first of a series of Annual Records, and that for 1875 is already far advanced.

5. *Report on the Geology of a portion of Colorado examined in* 1873; by Prof. J. J. STEVENSON. 376 pp. 4to. Part IV of Lieut. Wheeler's Survey Report, vol. III. Published March 4, 1876.—Prof. Stevenson treats, in his report, of the general physical features of Colorado, of the various rock formations and mineral springs, and of the structure and age of the Rocky Mountain System and brings forward much that is of interest. Under this last head, the new conclusion is advanced that *there was an era of mountain-making in the Rocky Mountains at the close of the Carboniferous age*, synchronous with that in which the Appalachians were formed. The facts brought forward in its support appear to us to be too few and from too limited an area to establish fully its truth against the opposing statements of other Rocky Mountain investigators. If an epoch of mountain-making then occurred, it ought to be registered in an extensive series of obvious facts. We see in the Appalachians—in their breadth exceeding 100 miles, their length several hundreds, with upturnings everywhere—an example of an *individual* mountain-chain (i. e., one made in a single mountain-making operation); and also a display of the manifest evidences of disturbance which such an area should bear. We have, further, an illustration of the fact that such an "individual" cannot have narrow confines, because the crust of the earth has been—certainly since Silurian times—too thick to bend in a narrow trough or geosynclinal (the trough in which the deposits constituting the mountains were accumulated). We shall look with great interest for the results that may hereafter be published by other observers on this interesting question. J. D. D.

6. *Das Gebirge um Hallstatt.* Erster Theil; Die Molluskenfaunen d. Zlambach und Hallstätter-Schichten. II Heft mit 38 Lith. Tafeln. Von EDMUND MOJSISOVICS von Mojsvár, Chef-Geologen d. k. k. geol. Reichsanstalt. 4to. Vienna, 1875.—This part of the great work on the peculiar fossil fauna of the renowned locality of Hallstatt is worthy of its predecessor previously noticed in this Journal. It contains the most complete series of figures and descriptions of the genus Arcestes yet published. Thirty-four plates are devoted to the illustration of this group and the specimens are, for the most part, very perfect. This has enabled the author to exhibit a very perfect series of a multitude of various forms all

having perfect apertures, and his plates are the most perfect demonstration, which we have yet seen, of the importance of the contours of the aperture in the classification of sub-groups. The author divides the genus Arcestes into several divisions according to the peculiarity of the sutures and gives complete tables of the geological and geographical distribution of the species. In fact the stratigraphical paleontology is treated in the most perfect manner. Any criticisms of the zoology of the work would be out of place and inapplicable, since it is essentially, as are all the later German paleontological memoirs on this and kindred subjects, paleontological geology; the differences of the animal remains being invariably the aim of all the researches, with the view of establishing data by which the different strata may be distinguished one from another, and the peculiarities of the faunæ noted. Two new genera are described, Didymites and Lobites. The latter being related to the true Arcestes in about the same way that Scaphites is to the typical Ammonites. Whether this will eventually hold or not is doubtful, since, as Quenstedt has shown in his master-work on the Jura, such forms are intimately connected with normal forms, sometimes not even specifically separable according to the generally accepted methods of classification. A. H.

7. *Rammelsberg: Handbuch der Mineral-Chemie.* 2d edition, 980 pp. 8vo. Leipzig, 1875.—The second edition of Rammelsberg's valuable work on mineral chemistry is an indispensable volume to all interested in the progress of mineralogy. The general plan adopted by the author is essentially that of the first edition (published in 1860), the most important changes being those which strict conformity throughout to the principles of the new chemistry has required. The first volume (136 pp.) contains the general treatment of the subject of mineral chemistry, with a detailed discussion of the principles of isomorphism and heteromorphism. The second volume (744 pp.) takes up the mineral species in order, giving under each the most of the analyses published, especially those of recent date. For each analysis the atomic ratios of the different elements have been calculated in full, and from them the formulas are deduced. The author has been so long an authority in mineral chemistry that his present conclusions on many disputed points, though occasionally appearing somewhat arbitrary, will have great weight with all. E. S. D.

8. *Einleitung in die Krystallberechnung*, von Carl Klein; *zweite Abtheilung*, pp. 209–393. Stuttgart, 1876.—The first part of Professor Klein's valuable work on crystallography was noticed in a recent number of this Journal, (III, xi, 68.) The present part includes a detailed description of the methods of calculation applicable to the monoclinic, triclinic, and hexagonal systems, the whole being characterized by the same clearness and thoroughness to which attention was before called. A chapter upon the drawing of crystals forms the conclusion of the work. E. S. D.

III. Botany and Zoology.

1. *Phœnological observations in Giessen;* by H. Hoffmann. (*Phänologische Beobachtungen in Giessen*, von H. Hoffmann.)—We do not know any single English word for the kind of observations here recorded, and therefore we shall adopt that which our author has borrowed from Greek. This pamphlet of 32 pages gives the date when the leaf and flower-buds of over two hundred plants opened; the fall of the blossom; the ripening of the fruit, and the fall of the leaves. The observations in some cases extend through twenty years or more. The author has also noted the dates of the appearance of butterflies, birds, etc. The author submits his work as a contribution to the store of facts required by the student of vegetable climatology, but does not give any conclusions of his own except the following:

In the case of plants in a given locality, the average of a few years is very nearly the same as the average of many, e. g.:

The "first flowers" of the following species appeared on the days given below as means:

Average	of 8 years,	of 13 years.
Geranium sylvaticum,	20 May,	19 May.
Triticum vulgare,	"	"
Average	of 15 years,	of 21 years.
Helianthus annuus,	26 June,	25 June.
Average	of 9 years,	of 14 years.
Primula elatior,	25 March,	25 March.

In only one of the cases collated is there to be observed a difference of more than one day.

Prunus avium, average of	8 years,	23 April.
"	14 "	21 "
"	21 "	19 "

G. L. G.

2. *Bulletin of the Bussey Institution, Harvard University.* Part V. 1876.—This finishes the first volume, of 453 pages, and is therefore properly supplemented by a copious index. In articles No. 18, 19, and 20, Prof. Storer continues his valuable and practical chemical papers—the notice of which we leave to another hand. Papers No. 21 to 24 are by Prof. W. G. Farlow, as follows:

On a Disease of Olive and Orange Trees occurring in California in the spring and summer of 1875.—It proves to be the work of a fungus, *Fumago salicina*, which has been known and given trouble in Europe since the year 1829. In an excellent plate Prof. Farlow represents the stylospores, mycelium, pycnidia, and conidia.

On the American Grape-Vine Mildew.—It appears that the *Oidium Tuckeri*, which has been so disastrous to the vines of

Europe and Madeira, and which is "the conidial form of some species of the *Ascomycetes*, probably some *Erysiphe*," although supposed to have come from America, is not a common or conspicuous infestor of our native vines; but that the commonest, at least in New England, is *Perenospora viticola*, which is limited to the leaves and stems, and does not attack the fruit. Being often found on every leaf, of a vine, it would be expected to injure the grape crop. "Such, however, is not the case. The fungus does not attack the grapes themselves, nor does it, at least in New England, appear until about the first of August, and its withering effect upon the leaves is not very evident before September. As far as out-of-door grape culture in the northern States is concerned, we are inclined to believe that, practically, no harm is done by *Perenospora viticola*, but that, on the contrary, the fungus is really beneficial. Our native vines have a luxuriant growth of leaves; and the danger is that, in our short summers, the grapes may not be sufficiently exposed to the sun to ripen. But the *Perenospora* arrives, with us, at a time when the vine has attained its growth for the season, the important point being then to ripen up the grapes which are concealed by the foliage. By the shriveling of the leaves, the *Perenospora* enables the sun to reach the grapes without loss to the vines, as is shown by the fact that the vines continue to live on, year after year, without apparent injury." The botanical history, literature, and forms of this fungus are fully illustrated, two plates show the structure and fructification of this and some allied species; and a synopsis of the half-dozen species of *Perenospora* detected in the United States, and five of *Cystopus*, is appended.

List of the Fungi found in the vicinity of Boston. Confined to the species which have come under the author's own observation.

The Black Knot (of Plum and Cherry trees). This interesting and important memoir is illustrated by three beautiful plates, showing this disease in various stages, and the whole structure, development and fructification of *Sphoria mortosa* of Schucinitz, the fungus which produces this black knot, which so deforms and injures plum and cherry trees throughout the Northern States and Canada. The remedy is the knife or the axe. For prevention Dr. Farlow recommends the extirpation of choke cherry trees, upon which the pest largely breeds in the vicinity of Boston. Farther west it would all the more be necessary to destroy all the wild plum-trees (*Prunus Americana*), which are fearfully infested.

No. 25, the last paper of the volume, is Prof. Sargent's

Report of the Director of the Arnold Arboretum;—from which we learn that: "Probably over 100,000 ligneous plants have been raised during the nine months," and as many as 5,542 trees and shrubs have been presented to various establishments and individuals throughout the United States interested in agriculture," besides those sent to Kew and elsewhere abroad. A catalogue of the species raised is appended. A. G.

3. *Nymphœa flava* Leitner.—The plate of Audubon's great work which represents the American swan likewise represents the flower of a yellow *Nymphœa*, or true water-lily, under the above name. The foliage which accompanies it may be that of a *Nuphar*, but the flower is that of a *Nymphœa*. Leitner was a German botanist who explored southern Florida, and died or disappeared there,—if we rightly remember, was thought to have been killed by Indians. He doubtless met Audubon and gave him the name which he published on his plate. The species has properly been left unnoticed so long as the whole evidence of its existence rested upon Audubon's figure of a flower accompanied as it is with *Nuphar* foliage. But of late years we have heard of a yellow water-lily in Florida. In 1874, Dr. Edward Palmer sent us a specimen with foliage and flowers collected in Indian River, and certified to the yellow color. It has now been detected by Mrs. Treat, on the St. John's River, and living plants communicated to us, from which we may expect to see fresh blossoms. The growth is very different from that of *N. odorata*, the rhizoma being shorter, and thickly beset with salient blunt tubercles; and the plant propagates freely by stolons. A. G.

4. *Note on some of the Starfishes of the New England Coast;* by A. E. Verrill.—In the Archives de Zoologie Experiméntale et Générale, vol. iv, Nos. 2 and 3, 1875, M. Edmond Perrier has published a very useful and important paper entitled "*Révision de la Collection de Stellérides du Muséum d'Histoire Naturelle de Paris*," in which he has redescribed many of the types of Lamarck, J. E. Gray, Müller and Troschel, and others, as well as many new species, and has also added many remarks on various genera and species, as well as upon their classification, etc. At the present time I do not propose to discuss this memoir, as a whole, but wish to call attention to some errors into which the author has fallen concerning our common New England species, owing chiefly, doubtless, to his not having a sufficient number of well preserved specimens to form any clear ideas of their true specific characters and great variability.

Every naturalist who has occasion to collect and study any considerable number of living specimens of any of the larger species of *Asterias*, especially if from different localities or varying stations, must be deeply impressed by their extreme variability, not only in size and color, but in the form and relative length of the rays, character of the dorsal spines, number of pedicellariæ, etc. Moreover, if he has had occasion to preserve large numbers of specimens, both in alcohol and by drying, he must have observed the very different forms and appearances that specimens, quite similar when living, will assume, whether owing to the various states of contraction in which they die, or to the mode in which they are afterwards preserved. Thus similar living specimens may be killed and preserved so that one will have slender tapering rays; another, rays smaller in the middle and constricted at base; another, rays swollen at base and pointed at

tip; some will die with swollen disk; others with contracted disk; some will have the rays collapsed and flattened; others will have them round and plump, or angular; some will have the spines erect; others, more imperfectly preserved, will have them flattened down and more or less detached. Moreover, the plates in some will be so closely drawn together by the contraction of the muscles of the skin as to give them a rigid character, while others, perfectly identical if they die in a relaxed or inflated condition will have the plates separated by the looser integuments so as to give them an openly reticulated appearance, with wider naked spaces between the plates. Hence all such characters should be used with great caution.

It is, therefore, evident that any naturalist who would correctly limit the species in this group should at least have a very large number of specimens preserved, as well as possible, in various ways, and still better, when possible, he should collect large numbers of the living specimens and after studying them in life and making notes upon them he should preserve, and afterwards compare them with his notes. In this difficult group there are probably no species more variable and perplexing than those forms allied to *Asterias rubens* of Europe, and *A. vulgaris* and *A. Forbesii*, the common New England species. And yet in this very group M. Perrier attempts to decide the specific characters of our species, and to correct their synonymy after an examination of very few (sometimes only one), and often very badly preserved dry specimens (*A. pallidus*). And in doing this he relies on characters that are notoriously variable, and even upon those accidental features due to modes of preservation, as stated above.

As M. Perrier particularly refers (pp. 354–7) to my own views in regard to our native species, as expressed in several former papers,* and seems to think it strange that my conclusions in 1873 differed slightly from those held in 1866, I may be pardoned for stating that during the ten years that have elapsed since my first paper on the subject was published, these starfishes have been collected, studied, and preserved by me in very great numbers, and from hundreds of localities, during the various dredging expeditions that I have undertaken along our coast, some of which have been noticed in former volumes of this Journal. Therefore, having carefully examined many hundreds of specimens, in all conditions, and having taken ten years to consider the matter and to discuss it with others, I feel perfectly confident that M. Perrier has made at least five American "species" out of specimens that actually represent but two. These errors would have been more excusable had they not been made subsequently to my revision of the synonymy, for he might have supposed that my materials were far more ample than his own. The facts are as follows: Upon the coast of New England there are, as yet known,

* Proceedings Boston Society of Natural History, vol. x, p. 333, 1866; Report on the Invertebrata of Southern New England, Report of U. S. Commission of Fish and Fisheries, Part I, 1873 (published March, 1874).

but three species of *Asterias*, belonging to the littoral zone and shallow waters, though two or three other smaller species (*Leptasterias*) occur in deep water.* One of the shore species, *A. littoralis* (Stimpson), is a small species, rarely six inches in diameter, (belonging to the group, *Leptasterias*) found in the Bay of Fundy and northward to the Gulf of St. Lawrence, both between tides and in deep water, and although variable in form, size, color, etc., it has not yet led to much confusion. The two others are large and very common species—one southern and the other northern—but with their respective areas overlapping on the New England coast. One of these, *A. Forbesii* (Desor), extends from the Gulf of Mexico, to Casco Bay, Maine, and is the most common species on the southern coast of New England. The other, *A. vulgaris* (Stimp.), extends from Labrador (and probably farther north) to Long Island Sound, where it becomes rare; it is the most common species north of Cape Cod, and is very abundant on the coast of Maine and northward. Both species vary extremely in size, form, and color, even when living, and still more so when preserved by drying. The color of the faded dry specimen, which M. Perrier mentions as distinguishing "*A. Fabricii*" from "*A. berylinus*," is a perfectly worthless character, yet when living our two species can usually (but not always) be distinguished by the colors, for *A. Forbesii* (*berylinus*) is generally greenish, varying to orange and brown, with a bright orange madreporic plate; while *A. vulgaris* is usually reddish, purplish, or violet, varying to yellow and brown, but with a pale buff or cream-colored madreporic plate. Moreover, the colors and forms of each vary according to the sex, and the form varies according to the season, state of the ovaries, age, dilation with water, etc. The *forms* of the major pedicellariæ,† and of the adambulacral (or interambulacral) spines give the most available characters for distinguishing the two species under all circumstances, though the firmer skeleton of *A. Forbesii* is also an important and characteristic feature.

In A. Forbesii the major pedicellariæ are short, ovate, blunt-pointed, hardly longer than broad; the adambulacral spines are stout, obtuse, and in most cases many are more or less flattened, and grooved externally, at tip.

* It is proper that I should state that I have become satisfied that the species described by me as *A. Stimpsoni*, in 1866, was not well founded. The study of a far more extensive series of specimens has shown that the specimens thus named were somewhat peculiar small specimens of *A. vulgaris* (Stimp.), with which some young specimens of *A. littoralis* were also confounded, so that the characters given largely appertain to the young of *A. vulgaris*. It is probable that most of the specimens formerly distributed as *A. Stimpsoni*, were young of *A. vulgaris*, and such may have been those that M. Perrier says he has examined, though he considers it a good species.

† Dr. Stimpson, in 1862, (Proc. Boston Soc. Nat. Hist., vol. viii, p. 262, *note*) called special attention to the two peculiar forms of pedicellariæ, characteristic of this family, and to their importance in distinguishing the species. He termed the larger sessile ones, whether scattered over the surface or attached to the ventral spines, "*major pedicellariæ*," and the small pedunculate ones, borne in clusters on the spines, "*minor pedicellariæ*." In 1864–70 M. Perrier called the former, "*pédicellaires droits*," and the latter "*pédicellaires croisés*."

In A. vulgaris the major pedicellariæ are lanceolate, sharp-pointed, much longer than broad; the adambulacral spines are longer, more pointed, and seldom flattened.

The dorsal spines are variable in form and number in both species, but are usually more acute in the latter, though blunt and even clavate spines often occur on both species. The *number* of *minor* pedicellariæ on the spines, and of *major* ones on the back and also on the adambulacral spines, is extremely variable in both species. Yet these are the characters mainly relied upon by M. Perrier for distinguishing his supposed species. Three of the "species" recognized by him are evidently mere forms of *A. vulgaris*. These are *A. Fabricii* (Agassiz, MSS.), based on *one* dry specimen from Laborador; *A. pallidus* (Agassiz, MSS.) based mainly on six small dry specimens, sent, like the preceding, from the Museum of Comparative Zoology in 1864, and in a very bad state of preservation, the spines being mostly detached by partial decomposition during the drying of the specimen (which has misled M. Perrier, who imagined that they had been moveably articulated); and two large specimens that he refers to *A. vulgaris*, one from Beverly, Mass., and one in the British Museum. The latter was probably sent by Dr. Stimpson, who commonly used labels marked "Exploration of the East Coast of the United States" (not "west" coast, as M. Perrier gives the label), for his New England collections. I had given "*A. Fabricii*," after examining original specimens, as a synonym of *A. vulgaris* in my paper of 1866; and gave "*A. pallidus*" as an undoubted synonym in my Report of 1873–4. All the characters given by M. Perrier as distinctive are variable and partly accidental features that can be found, with all intermediate states, in any considerable collection of this species from a single locality. These manuscript names were given by Prof. L. Agassiz before he had made a very thorough study of the genus, but in a conversation, in 1871, while we were dredging in company in Vineyard Sound and obtaining both species in abundance, he fully agreed with me that there were *only two* large species of this group known on our coast, and he also positively identified the numerous good specimens of *A. vulgaris* with his *A. pallidus;* and likewise the *A. Forbesii* (or *arenicola*) with his *A. berylinus*. Dr. Wm. Stimpson in a conversation with me not long before his death, also agreed with these decisions. Had M. Perrier examined a good series of specimens he also would surely have found it impossible to have made the useless distinctions that he now proposes, based on such very insufficient material. In my Report of 1873–4 I stated that *A. Forbesii* and *A. arenicola* are "probably identical," the differences noticed (mainly in form and color) "being, perhaps, chiefly sexual," but not desiring to make premature changes, I left them under the two names, only because I had then no time to determine whether the differences are sexual, or properly varietal, or due to local or individual variations. Subsequent studies have satisfied me that the differences are mainly individual or casual and very incon-

stant, so that there is no longer any reason for distinguishing the two even as varieties, yet M. Perrier not only keeps them distinct, as two species, but names another slight variation as a distinct variety of *A. arenicola.*

There is now little doubt in my mind that *A. vulgaris* will prove to be identical with *A. violaceus* of Northern Europe, and that the latter may be, as many believe, a mere variety (or sexual form) of *A. rubens.* But M. Perrier considers these distinct species, though with some doubt as to *A. violaceus.*

That, in other cases, he has admitted, as valid species of *Asterias*, forms that are scarcely varietal is very probable, judging from his descriptions alone, for the distinctive characters that he gives are frequently those that are most apt to be variable. He has described a single dry Labrador specimen of *A. polaris* (from Dr. Packard's collection) as a new species under the name of *A. borealis.* But among a large number of fresh specimens observed by me at Anticosti Island, there were various forms intermediate between his specimen and what he regards as the typical *A. polaris* from Greenland. Moreover, the several Labrador specimens that I have examined, collected by Dr. Packard at the same time with the one now described as *A. borealis*, show great variations in the form of the spines, length of arms, and number of pedicellariæ,—characters that M. Perrier regards as distinctive in this case. Therefore there is good reason to believe that his *A. borealis* is only a form of *A. polaris*, to which American zoölogists have hitherto referred it.

Throughout the paper there are numerous typographical errors, many of them due to imperfect proof-reading, but others more important are due to careless references to the papers of other writers, especially those in English. "Contributions to the Zoology of Yale College" is scarcely a legitimate substitute for the "Contributions to Zoology from the Museum of Yale College," published in this Journal. The locality, Eastport, Maine, is once given as "East Port (Massachusetts,)" and once as "East Port, (Canada.)"

In one respect the nomenclature adopted, in some cases, by M. Perrier is very objectionable, for he attempts to restore some of the ante-Linnæan "names" of species used in 1733 by Linck, who was not, in any sense, a binomial writer, and whose polynomial (or accidentally binomial) phrases can have no claim to priority, as specific names, under the binomial system.

5. *Hæckel's theory (Allœogenesis) of the genetic connection between the Geryonidæ and Æginidæ.*—In the Proceedings of the Elliot Society for 1857, McCrady gave a very interesting account of the commensalism of the young brood of a Cunina and of Turritopsis. No notice was taken of this remarkable mode of development, McCrady's observations having been discredited by the later publication (1865) of a magnificently illustrated memoir on the "Rüssel-quallen" by Hæckel. The startling hypothesis of the genetic connection between the Geryonidæ and Æginidæ contained

in this memoir and called by Hæckel allœogenesis, has been ever since a stumbling block to all theories of genetic relationship among Medusæ.

Two short papers recently published, the one by Schulze (Nat. Wiss. Ver. f. Steiermark, 1875, p. 125), and the other by Uljauin (Archiv f. Naturg., 1875, p. 333), have, however, proved conclusively that Hæckel's theory, like many other of his vagaries, had no foundation of truth. It was based not merely on an incorrect interpretation of facts, but the facts themselves existed only in his imagination.

As, perhaps, with the exception of his monograph of the Radiolaria, no other memoir has contributed more than the one above quoted to give Hæckel the position he holds among zoölogists, we may be allowed to remind the Hæckelian school of naturalists that this same genetic connection has furnished the text for many a sermon from their high priest. Infallible himself, he has been unsparing in his condemnation of the ignorance and shallowness of his opponents. Proved now to be in the wrong, we expect therefore justice without mercy from this stern scientific critic, and look forward in the next number of the Jenaische Zeitschrift for a thorough castigation of Hæckel by Hæckel, showing up the absurdity of allœogenesis and all that hangs thereby.

ALEXANDER AGASSIZ.

6. *Animal Parasites and Messmates;* by P. J. VAN BENEDEN. 274 pp. 12mo, with 83 illustrations. 1876. New York. (D. Appleton & Co.) The International Scientific Series.—The author of this work is an able Belgian zoologist, well versed in the subject of which he writes. The subject is treated in a popular style, and cannot fail to interest. The facts presented are some of the strangest that have been brought to light by recent investigations, and not the least marvelous are those relating to man's parasites.

7. *The Journal of Anatomy and Physiology*, conducted by G. M. HUMPHREY, M.D., F.R.S., Prof. Anat. Cambridge, Wm. Turner, M.B., Prof. Anat. Edinburgh, M. Foster, M.D., F.R.S., Prælector Physiol., Cambridge, and Wm. Rutherford, M.D., Prof. Inst. Med. Edinburgh. January, 1876, vol. x; part II, pp. 223–458, with 8 plates. Cambridge and London. (MacMillan & Co.)—The tenth volume of this able scientific quarterly commenced in October. The January number, recently issued, contains the following papers: On the anatomy of the lens, by Dr. Thin and J. C. Ewart (pl. ix); anatomy of the Lineidæ (Nemerteans), by Dr. McIntosh (pl. x–xiii); experiments on the biliary secretion of the dog, by Dr. Rutherford and M. Vignal; the transformations of the pulse-wave in the different arteries, by Dr. Galabin (pl. xiv); on the broncho-œsophageal and pleuro-œsophageal muscles, by Dr. Cunningham; the summation of electrical stimuli applied to the skin, by Dr. Stirling; development of Elasmobranch fishes, by F. M. Balfour (pl. xv, xvi); craniofacial apparatus of Pteromyzon, by Prof. Huxley (pl. xvii, xvii); secondary arches of the foot,

by S. M. Bradley; note on the placental area in the cat's uterus after delivery, by Prof. Turner; notices of books; report on the progress of anatomy, by Prof. Turner and D. J. Cunningham, M.B.

8. *Bulletin No.* 2, of the U. S. Geological Survey of the Territories, contains two papers by R. Ridgway, entitled Studies of the American Falconidæ, and Ornithology of Guadeloupe Island, illustrated by two plates.

III. Astronomy.

1. *Observations of the planet Jupiter.*—The Royal Astronomical Society of London have appointed a committee whose object shall be to endeavor to enlist observers in making drawings of the appearance of the planet Jupiter, and to obtain as extensive a series as possible of such drawings. The committee has issued a circular, and prepared, for the sake of uniformity and convenience, blank forms upon which the drawings can be made. Drawings and communications should be sent to the "Secretary of the Jupiter Committee," Royal Astronomical Society, Burlington House, London, W.

2. *Repertory of works in Pure and Mixed Mathematics.*—Doctors Kœnigsberger and Zeuner of Dresden, propose to collect, as far as possible, and publish "longer or shorter detailed reports written by the authors themselves upon their own books and treatises" in the mathematics. The reports will comprise articles on the entire field of mathematical research: Pure mathematics, and all the collateral branches of the mixed science, such as: astronomy and geodesy, mathematical physics, analytical and technical mathematics, all mathematical branches of engineering, mathematical statistics, etc.; besides which the editors intend to have the reports printed in the language in which they are sent to them by the author, taking it for granted that such reports in German, English, French, or Italian will be intelligible to scientific men of all countries.

They propose to begin with reports on all books and memoirs which have appeared since Jan. 1st, 1875. The "Repertory" will at first be issued in numbers, at irregular intervals. H. A. N.

IV. Miscellaneous Scientific Intelligence.

1. *The American Cyclopædia.* Vol. xv. SHO–TRO. D. Appleton & Co., New York. 1876.—The first volume of this edition of Appleton appeared in July, 1873. One volume more will complete the work, making in the aggregate nearly 15,000 pages of text. Among the articles in the fifteenth volume interesting to scientific readers we note particularly *steel*, by Dr. Droun; *silver*, by Dr. Raymond; *sound*, *spectrum* and *stereoscope*, by Professor Mayer; *sun*, by Professor Langley; *tides*, by Mr. Hilgard; *snow*, *storms* and *trade-winds*, by Cleveland Abbe; *telegraph*, by Professor Lovering; steam, steam-boiler, carriage, engine and navi-

gation, and strength of materials, by Professor Thurston. Numerous astronomical articles are furnished by R. A. Proctor, of London: e. g. spectrum analysis, sun (in part), &c. The medical and physiological articles are mainly by Dr. J. C. Dalton, while other well-known names add authority to the contents of this volume. We have in former notices called attention to the large amount of special work performed for this edition of Appleton's Cyclopedia by men of acknowledged ability and original research in the departments of which they treat. The foregoing list is in evidence that this character is fully maintained. The maps and wood-cuts are numerous and excellent in quality. B. S.

2. *Annual Report of the Light-House Board to the Secretary of the Treasury for the year* 1875. 136 pp. 8vo. Washington, 1875.—The executive members of the Light-House Board are Professor Henry, Commander J. G. Walker, U. S. N., Naval Secretary, and Major P. C. Hains, Engineer Secretary. The report for 1875 contains "an Account of the investigations of the Light-House Board relative to illuminating materials, by the Chairman of the Committee on Experiments." Lard-oil had been in former experiments found to be the best illuminating oil; and this conclusion is sustained as regards the large lamps by new comparisons of lard oil with the best mineral oil, though not as regards the smaller. On account of the increased expense of lard oil, the mineral oil will hereafter be introduced. There is also another of Professor Henry's valuable papers containing the "Investigations of the Board relative to sound in its applications to fog-signals," made under his direction in 1875.

3. *Meter-Diagram.*—Messrs. A. & T. W. Stanley, of New Britain, Conn., well known as makers of accurate measures of length, levels, etc., have lately prepared a neat meter-diagram, printed on heavy paper faced with linen, with the scales and tables on both sides, and 4¼ inches wide. It gives in a complete manner the entire metric system, with the relations of feet and inches to the meter and its subdivisions, and in the appended tables the equivalents in denominations in use, with rules for conversion. Professor Newton says of it: "I know of no easier way by which anyone desirous of learning the system can do it, than by studying this scale, and keeping it in a place where he will frequently see it." It is put up in a paper case, and sold at the moderate price of three dollars per dozen, for use in schools, etc.

Handbook of Architectural Styles. Translated from the German of A. Rosengarten by W. Collett Sandars. 502 pp. 8vo, with 639 illustrations. 1876. New York. (D. Appleton & Co.)—An excellent, and profusely illustrated work.

A Short History of Natural Science and of the Progress of Discovery from the time of the Greeks to the Present Day, for the use of Schools and Young Persons; by Arabella B. Buckley. 488 pp. 12mo, with illustrations. 1876. New York. (D. Appleton & Co.)—An instructive work.

Physics of the Ether. By S. Tolver Preston. London. (E. and F. N. Spon.) 1875. 8vo, pp. 136.

Geological Survey of Pennsylvania. Report of Progress in the Clearfield and Jefferson District of the Bituminous Coal-field, by F. Platt, 296 pp. 8vo, with maps and sections.

OBITUARY.

A. R. MARVINE.—Mr. Archibald R. Marvine, the geologist, died in Washington, March 2d, 1876. He was born at Auburn, N. Y., Sept. 26, 1848, and while a youth attended the military school at Sing Sing, and subsequently the School of Technology at Philadelphia. He then entered the Hooper Mining School of Harvard University, from which he graduated in 1870, when he was appointed instructor in the same school, a position which he held until July, 1871. He was one of the students who went with Professor Whitney, to make practical studies in geology and geography in the Park Mountains of Colorado, in 1869.

In the summer of 1870, Mr. Marvine was appointed assistant-geologist to attend the celebrated Santo Domingo Expedition, and on his return he prepared a brief report on the geology of the island, which was published, with the other reports relating to Santo Domingo affairs, by order of Congress.

In July, 1871, he received the appointment of astronomer to the Wheeler Expedition, in which capacity he served several months, while that work was in progress, and then continued as a member of the Expedition in the capacity of geologist. His report on the geology of a district of country through which he passed, embraced in southern Nevada, northwestern Arizona, and southern California, has lately been published by authority of Congress.

His next geological work was in the Keweenaw copper region on the shore of Lake Superior, under the direction of Professor Pumpelly, and his report was published by authority of the legislature of Michigan.

In March, 1873, he was given a position as geologist in the corps of the U. S. Geological and Geographical Survey of the Territories under Dr. Hayden. In this capacity he made a careful survey of a region embracing Middle Park and extending eastward across the Front Range to the foot hills. His published report on this work gives evidence of thorough preparation, great labor and much skill, in the collection of material, and ability in its use. After preparing his report on the Middle Park district, he returned to Colorado Territory for the purpose of extending his investigations into a region of country west of Middle Park on the headwaters of the Grand, White, and Yampa rivers, and entered into his labors with great vigor and enthusiasm. But a long summer of toil and privation in that wilderness of cañons, crags, and peaks, undermined his health, and shortly after his return, early in the winter of 1874–5, he was prostrated with an attack of rheumatic meningitis from which, after many weeks of suffering, he partially recovered, but was not again able to resume his work, and early in December last he relapsed into a condition that was soon found to be hopeless.

Mr. Marvine leaves behind a large circle of friends, among the working scientists of the country, who had learned to expect great and valuable results from his researches. G. K. G.

APPENDIX.

ART. LIII.—*On some Characters of the genus Coryphodon* Owen; by O. C. MARSH.

THE lower Eocene deposits of England and France have yielded a few remains of an interesting genus of ungulate mammals to which Owen, in 1846, gave the name *Coryphodon*.* Hébert subsequently published a memoir on the subject, in which he figured and described the more important specimens found in France.† Although comparatively little is yet known in Europe of the structure or near affinities of these animals, the portions preserved are characteristic, and the genus is well marked. The geological horizon, also, is fully determined, viz: the London clay of England, and, in France, the base of the *Argile plastique*.

While in Wyoming with the Yale College exploring party in 1871, the writer had his attention called to a deposit at the base of the Eocene containing mammalian remains, and subsequently obtained a number of the fossils, mainly through the kindness of Wm. Cleburne, Esq., who sent other specimens to the Academy of Natural Sciences in Philadelphia. Some of the latter fossils were described by Prof. Cope as *Bathmodon radians* and *B. semicinctus;* and in the same paper another generic name, *Loxolophodon*, was proposed for the same lower molar named as the second species.‡ Since this time, other similar remains have been found in Utah and New Mexico, and their principal characters can now be determined.

An examination of an interesting series of these fossils now in the Yale Museum, including some portions of the same individuals described by Prof. Cope, clearly shows that they all belong to the genus *Coryphodon* of Owen. This is especially important, as the geological horizon of the remains is essentially the same in both countries, and the American specimens promise to clear up many doubtful points in regard to the animals themselves. One of the specimens in the Yale collection is a nearly perfect skull, representing an undescribed species

* British Fossil Mammals and Birds, p. 299.

† Annales des Sciences Naturelles, tome vi, p. 87, Plates III and IV, 1856.

‡ Proceedings American Philosophical Society, p. 420. 1872.

which may be called *Coryphodon hamatus*. It indicates an animal somewhat larger than a tapir. The more important characters derived from an examination of this cranium, and some other remains of the same genus, are as follows:

The skull is elongated, the facial portion being most produced. A basal line extending from the lower margin of the foramen magnum along the palate to the end of the premaxillaries is nearly straight. The zygomatic arches are much expanded, but the malar is comparatively slender, and joins the maxillary in front of the orbit. The latter is of moderate size, and confluent with the large temporal fossa. The general form of the skull is indicated in the cut given below, figure 2. The maxillaries are massive, and on the sides behind the canines are deeply indented, giving a marked constriction to this part of the skull. The lachrymal forms the anterior border of the orbit, and its foramen is inside the orbital margin. The nasals are quite slender in front, and broad posteriorly. The premaxillaries are expanded transversely, giving a wide anterior narial aperture. The anterior palatine foramina are small, (figure 2.) The posterior nares extend forward between the last upper molars. The dental formula is as follows:

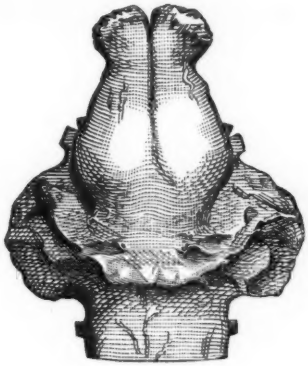
$$\text{Incisors } \frac{3}{3};\ \text{canines } \frac{1}{1};\ \text{premolars } \frac{4}{4};\ \text{molars } \frac{3}{3};\ \times 2 = 44.$$

The teeth agree in all generic characters with those figured as *Coryphodon* by Owen and Hébert. The occipital condyles are well separated, and there is a condylar foramen. Between the basisphenoid and the periotic, there is a large opening, partially due to the divergence downward of the inner faces of the latter bones. There is a strong paroccipital process, and a postglenoid process, which varies in size in different species. In *Coryphodon hamatus*, it is long, and curved forward, and to this the specific name refers. The skull as a whole presents strong Perissodactyle characters.

The brain cavity in *Coryphodon* is perhaps the most remarkable feature in the genus, and indicates that the brain itself was of a very inferior type. It was quite small, as in all Eocene mammals, but its most striking features were the small size of the hemispheres, and the large expanded cerebellum. The form and relative size of these are shown in the accompanying cuts, figures 1 and 2.

The olfactory lobes were large, and entirely in advance of the hemispheres. They were bounded in front by a well ossified cribriform plate, and partially separated by a vertical bony septum. The cerebral lobes were ovate in form, and very small, a transverse section exceeding but little that of the medullar opening. In shape and relative size, the hemispheres and olfac-

1.



2.

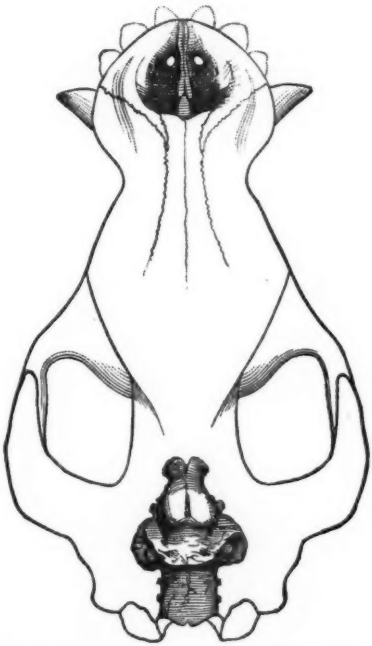


Figure 1.—Cast of brain-cavity of *Coryphodon hamatus* Marsh; top view. One-half natural size.

Figure 2.—Outline of skull and brain-cavity of *Coryphodon hamatus;* top view. About one-fifth natural size.

tory lobes of this genus are somewhat similar to those of *Dinoceras*. The cerebellum was proportionally large, and widely expanded transversely. Its peculiar form is shown in figure 1, which is drawn from a cast of the brain-cavity of *C. hamatus*. This portion of the brain nearly or quite equaled the hemispheres in size, thus differing widely from any known mammal. There is a well marked pituitary fossa, but no clinoid process. The foramina for the exit of the optic nerves are small, but for the others very large. The brain as a whole was very low in grade, and precisely such as might be expected in a mammal from the oldest tertiary deposits.

The skeleton of *Coryphodon* (*Bathmodon*) presents many features of interest, but only a few can now be mentioned. The limbs were comparativly short, and the femur has a third trochanter. The feet are especially interesting, as they present a primitive or generalized type. The manus and pes had each five short digits.*

The various characters shown in the skull and limbs of *Coryphodon* indicate that the animals of this genus were essentially five-toed Perissodactyles. They evidently represent a distinct family which may be called *Coryphodontidæ*. Their geological horizon in this country is near the base of the Eocene, in the deposits named by the Survey of the Fortieth Parallel, under Clarence King, the Vermillion Creek series. The remains of the family at present known in this country are from Utah, Wyoming, and New Mexico.

Yale College, New Haven, April 15th, 1876.

* Prof. Cope has recently published (Catalogue of Eocene Vertebrata from New Mexico, p. 28, 1875), a figure of the "Hind foot of *Bathmodon*," which is incorrect in several respects, the hallux, for example, having *three* phalanges!